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PROCEEDINGS

OF THE

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NAVAL INSTITUTE.

VOLUME XIV.

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ANNUAL ADDRESS, 1888.

By Rear-Admiral S. B. Luce, U. S. Navy, *President of the U. S. Naval Institute.*

To the Officers and Members of the U. S. Naval Institute:

When notified, some weeks ago, of my election as President of the U. S. Naval Institute, my time was so much engrossed with other matters as to admit of a brief letter of acceptance only. But now, with more leisure, it seems proper that I should address you somewhat at length, more with a view to testifying my appreciation of the compliment implied by my election, than with the hope of contributing anything of value to the long list of essays which enrich the pages of the Quarterly.

On the establishment of the Newport Branch of the Institute, April 3, 1883,* I took occasion to review the work of the Institute and to congratulate its officers, and the editors of the Quarterly, on the marked success of the enterprise. And now, looking back over the intervening years and noting the continued success which has marked its career, I find every reason for renewing those congratulations. But the Institute is of too recent growth to warrant much indulgence in retrospection. Let us look ahead.

* Vol. IX, No. 5, 1883. Article, "War Schools."

The fundamental idea in the establishment of the Institute is "the advancement of professional and scientific knowledge in the Navy," and that purpose is being accomplished year by year in a praiseworthy manner. Hence, the efforts of those who originated the Naval Institute have been marked with success, and much credit is due to them and to their successors for the management of its affairs. Established now on a firm basis and with a paying subscription list, its future, in a literary point of view at least, has long ceased to be doubtful.

It is to be noted that the success of the Board of Control is due to individual exertion—exertion carried on oftentimes against great odds, bringing the authors of the enterprise to the very verge of despair. They have succeeded, nevertheless.

Opposition sometimes proves a wholesome stimulant. It seems to confirm men of character in their opinions when those opinions are founded in reason, and renders them more determined in the prosecution of their plans. At the same time it causes them to be more circumspect in the prosecution of those plans, and to elaborate them more maturely and on broader and deeper foundations, where otherwise they might have been superficial and ephemeral. Hence, it may, and often does, occur that an open and an outspoken opponent proves in the end to be no small factor in the successful development of an enterprise. It is true, the value of this opposition is not always apparent—like those blessings so thoroughly disguised as to be wholly indiscernible by ordinary methods of examination—while there are occasions when opposition may easily prove fatal to the best laid schemes, let their merit be what it may.

The history of the Institute only adds one more to the many proofs that if the germs of the plan are endued with vitality, the plan itself may be pushed through the most formidable opposition to ultimate success. The Naval Academy itself is a marked example of this passing through a "sea of troubles" only to emerge with the crown of victory. These are lessons to be taken to heart.

But opposition is not always necessary to a healthy development. Indeed, it may retard or stifle growth, or even destroy the living germ. The Navy can furnish abundant illustrations of this. And this suggests the pertinent question, Are we not, as a body, wanting in discipline—that discipline which subordinates the individual to the body corporate, the part to the whole, and closes the mouth of opposition to lawfully constituted authority?

If a few undertake to build up, there are never wanting those who are ready to pull down—apparently from a sheer love of pulling down. The personal element, moreover, is such a strong feature of the work of destruction, that it is sufficient to know that A is endeavoring to achieve something for his profession, in order to incite B to oppose him. Both the principle on which A is working and the manifest advantage of his work are lost sight of in the naked fact that A is the active agent. That one fact is enough to arouse the most determined hostility of B. Like blind Samson he will pull down the pillars of the house though it involve his own destruction. This introduction of the personal element in our official relations, whether it has its origin in "envy, hatred, malice, and all uncharitableness," or is born of a conscientious sense of right regarded with a strabismic sense of sight, it yet exists; and in England, if not in our own country, its evil influence has been so far conceded, that the popular judgment would exclude a naval officer from presiding over the destinies of the Navy, and this notwithstanding the history of such great naval administrators as Admirals Lord Anson, Lord Hawk, the Earl of St. Vincent, and Lord Barham.

But the jealousies which prevent our officers from working in harmony for the common good, however inimical to progress, are not the evidences of a want of discipline such as has been hinted of. It is rather the interference of irresponsible parties with the measures of the Government. It is not wholly unknown to the annals of our history that an officer has on his own responsibility procured the introduction of a bill in Congress which, if passed, would affect the entire personnel of the service. It matters not how the provisions of the bill may interfere with others or with the policy of the Government—in this case the Navy Department; and though the great mass of such bills are predestined to those great catacombs of dead hopes, the document rooms of the Capitol, yet the mere fact of its introduction is evidence of an interested party working on independent lines, and not in concert with, indeed often in defiance of, the Department. This is in itself bad enough as an exhibition of lax discipline, but the worst phase is when officers set themselves to work avowedly to defeat the measures of the administration before Congress when those measures do not happen to be in accord with their individual opinions. Certainly no profession, as a whole, can hope to achieve an enviable distinction under such disturbing influences as these. It is like the house divided against itself, or an organism carrying within itself the seeds of its own destruction.

In justice let it be said as a class we are not responsible for this state of affairs. It is due entirely to the peculiar system under which we exist, or, in plain terms, to the absence of a proper form of naval administration by which the Navy may be held together and its policy shaped. There being no directive force to guide the affairs of the Navy—no head, no leader, every one is, in a measure, compelled to act for himself. As there is "no fraternity without a common father," so there can be no following without leadership. The absence of headship loosens the ties of membership and forces into existence independent action. This leads to self assertion and individualism, and individualism leads to anarchy. I do not say we have reached the ultimate stage; I say we are on the road which leads to it. This may not have a pleasing sound, but it is true.

Bad as this is in times of profound peace, it would be simply intolerable in time of war. Indeed, it would be an impossible condition in war. We present to the world, then, the extraordinary spectacle of having a war marine under an organization confessedly unfit for war; and yet we are called a practical people! How this utter disregard of business principles entails enormous expenditures and make-shift expedients is well known. Says Mr. Secretary Welles, writing of the condition of the Navy in March, 1861: "There were no men to man our ships, nor were the few ships at our yards in a condition to be put into immediate service."

The Virginius affair threw us into a panic and cost the country five millions of dollars. Mr. Welles attributed the low condition in which he found the Navy at the breaking out of the Rebellion, to the "disunion element" which had for previous years shaped public policy. It is only at a comparatively recent date that we have come to discover that the "disunion element" is in the Navy Department, though not in the sense in which he used the words. In a recent official document* it was shown that since 1868 about seventy millions of dollars has been thrown away upon the Navy. But it is not a waste of public funds alone that is chargeable to our present defective system. The evil at the head permeates the entire body, relaxing, as already shown, the restraints of discipline and leading to a prodigal waste of vital forces.

Now the corner stone of the Institute is the "advancement of professional knowledge in the Navy," but what is the use of knowledge if it cannot be applied? It is the application of knowledge that makes

* Report of Secretary of the Navy, 1885.

it valuable. We may go on *ad infinitum* publishing admirable essays, and much important information may be disseminated throughout the service, and many excellent and thoroughly practical suggestions may be spread over the pages of our Quarterly, but what substantial good do they do to the profession? How do they contribute to the progress of the Navy as a body? Let us take any one of the prize essays, for example, and consider for a moment its practical utility in affecting the Navy.

Outside its own special sphere, there is no subject of such vital importance to the Navy as our merchant service. The prize essay for 1882 was entitled "Our Merchant Marine; the Cause of Its Decline and the Means to be Taken for Its Revival." Let us now suppose that from the eleven essays presented to the judges of award there had been deduced a sound and practicable solution of the question, what should have been done with the paper? To whom should it have been presented with any hope of its receiving consideration? There is no one. You have fired your gun, but the shell has burst harmlessly in the air.

For a simpler illustration let us take the prize essay of 1886, "What Changes in Organization and Drill are Necessary to Sail and Fight Most Effectively our War Ships of the Latest Type?" and suppose, moreover, that the essay receiving the prize is a complete solution of the question—what comes of it? Nothing.

The question for the Institute to ask of itself, then, is: Can we continue forever to disseminate useful knowledge without a hope of substantial benefits to result therefrom? If we are to be known by our fruits, we must be able to show them. It is idle to go on sowing with never a hope of reaping. There must come a time when, in answer to the question, "What has the Institute accomplished?" we can point to reforms and progressive steps which will keep the profession abreast, if not in advance, of the nautical world in the great march of events. Hence there must be some power with which the Institute can feel itself in sympathy—a power that will have the eye to see, the ear to hear, and the understanding to act, and that power must be a controlling power. It must be at the head and must dominate the members. Then may we look for steady progress according to some recognized system. For no one at all familiar with our history will be deceived for one moment by an occasional spasmodic effort at rehabilitation under present conditions. How are we to attain this end?

Says the highest official authority, in regard to our need of naval administrators to shape our naval policy, "At the top of the system there should be wise general direction." With regard to the office of Secretary of the Navy: "The Secretary may at once be eliminated from the problem: a civilian, not skilled in the art of war, nor having any technical knowledge with reference to its implements, having no personal staff, his separate office consisting of but one stenographer, one clerk, and three messengers, all the other force having general clerical work." Of the Chiefs of Bureaus: "The inevitable result of throwing large executive duties upon any man is to disqualify him for council. At the present time this function is not performed at all." "Thus it happens, as it has happened for the last twenty years, that the Department drifts along, doing without consideration whatever is done and with no intelligent guidance in any direction."*

The vicious system which has so long usurped the place of a naval administration was so forcibly presented in the Report of '85 as to draw from the Chief Executive the remark that "the conviction is forced upon us with the certainty of mathematical demonstration that before we proceed further in the restoration of a Navy we need a thoroughly reorganized Navy Department." This was in 1885.

What has been done since? A bill was drawn up containing the leading features of such a form of naval government as was shown to be consistent with the principles laid down. The Report of 1886 says of it, "A bill embodying the substantial points awaits action upon the House calendar," and there it remains. Now it is not susceptible of proof, but the probabilities are that the bill was killed by influences not entirely foreign to the Navy itself. I would not be understood as saying that the bill would have been favorably considered by the House even had it received the approval of the Navy at large. Far from it. The Navy might have been unanimous for the bill and still it might not have reached a second reading. But naval officers, like members of other professions, have friends in both houses of Congress, and they can make their own personal representations to those friends; and whereas it is difficult to procure the passage of any bill, it is comparatively easy to defeat one, whatsoever merit it may possess.

Here then is a forcible illustration—one which would be startling but for its being so common—of the measures of the administration

*Report of the Secretary of the Navy, 1885.

being opposed, and as we believe successfully, by those whose loyalty it should be able to claim. But here again comes in the excuse, that the individuals are not so much to blame as the system under which they hold their official existence. Each one sets himself up for a judge of what is right and proper, without reflecting that allegiance is due to constituted authority, whether the acts of that authority are in accordance with their own views or not.

Moreover, views on the subject of naval administration are sometimes expressed in such an off-hand manner as to suggest much caution in accepting them. While some officers have made a careful study of the subject, others have given it but a passing thought. And yet the latter class will have no hesitation in the wholesale condemnation of the "bureau system," and bureaucracy in general, of a Board of Admiralty, or any other kind of board; an autocracy, or "one man power" in any form. Yet they do not hesitate to express their views, crude as they may be, to members of Congress. There are very few indeed who, without previous study, can draw up a sound, comprehensive form of naval government that will suit our condition, meet our present wants, and at the same time be unassailable on any just grounds.

It is just here that the Institute might render important service to the profession by enlightening the public mind of the Navy on this subject, through the medium of essays and frequent discussions. I am aware that there has already appeared in the pages of the Proceedings a paper touching on reorganization.* But the discussion which ensued embraced the entire personnel of the Navy, leaving little time or room for a critical examination of any one of the integral parts. If we limit the essay and discussion to one particular branch, and select at the outset the most important, we shall probably obtain a consensus of opinion as to what is really needed. Beginning at the top, therefore, it is believed that if an essay on the subject of "The Best Form of Naval Administration" was called for, the Institute would have the opportunity of disseminating throughout the service some useful information on the most important question which now concerns our profession. That such a discussion may lead to the first and most important step in the process of the rehabilitation of the U. S. Navy (the reorganization of our Navy Department), is not such a remote possibility as might at first glance be supposed. If the efforts of naval officers could bring about a reorganization in 1842, there seems to be no good reason why they should not accomplish the same in 1888.

* Naval Reorganization, page 491, Vol. XII, No. 4.

In both instances the initiative has been taken by the Department itself, with the great advantage, in favor of the present generation, of having such a medium of communication as the Institute's Quarterly. But while it is true that the Department took the initiative in 1840 in bringing about a reorganization, and that naval officers were largely instrumental in influencing action by which the bureau system was introduced, yet it should be distinctly understood that the Department was not remodeled wholly in accordance with the views of those who had been most active in bringing it about; and forty years of sad experience has shown that they were right.

The question then is: Shall the Institute endeavor, through its pages, so to influence and guide opinion in the Navy that we may, as a body, second the efforts of the Navy Department, and exert ourselves to bring about a correction of the error committed in 1842? It would be "a consummation devoutly to be wished," and if the Institute will take the lead and carry us on to victory, it will accomplish a reform of which its members may well feel proud.

It is scarcely necessary to add that even an ideal form of naval administration is not a sovereign cure of all ills. In the palmy days of the Board of Commissioners, four fine ships of the line rotted away upon the stocks simply because Congress would not give the money to finish them, and of the twelve laid down in 1815–18 only four ever got to sea. The settled policy of our national legislature, covered by a period of over a century, shows that war must be imminent and immediate before preparations to meet it are undertaken. But under the old regime, naval affairs were administered with wisdom and economy, the military character of the profession was maintained and discipline kept up; and that is all we can hope to regain.

The question I submit to the Board of Control is, Shall this great work be undertaken?

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

DECEMBER 8, 1887.

LIEUTENANT-COMMANDER C. S. SPERRY, U. S. N., in the Chair.

THE NAVAL USES OF THE PNEUMATIC TORPEDO GUN.

By CAPTAIN E. L. ZALINSKI, Fifth Artillery, U. S. A.

In appearing before the United States Naval Institute, I wish to present briefly to the officers of the Navy the general characteristics of the pneumatic torpedo gun and its possible fields of usefulness for naval purposes. Not a naval officer myself, I am aware that there may be many practical objections which would not be obvious to me. I am therefore desirous of suggestions and frank criticism from my brother officers of the naval branches of the service, with a view of determining where changes or modifications are requisite.

I desire to be clearly understood at the outset, that in no way is this weapon to be compared with powder guns nor in any way to replace them. When comparisons with the powder gun are made, therefore, it is simply for the purpose of weighing the chances of attaining the target.

This gun has been developed as a torpedo projecting machine, having many advantages over the torpedo appliances ordinarily in use. I do not claim for it superhuman certainty of action. It demands to be seconded by the brain of the human operator, who must be endowed with nerve and judgment, and skill derived from practice. This is the case with every appliance of war. The pneumatic torpedo gun is affected by the same *mal de mer* that the ordinary powder gun is subject to—a rolling and pitching platform demands judgment and skill on the part of the gunner as to the instant of firing.

Before entering more fully into the discussion it may be well to describe briefly the essential elements of the gun system, the torpedo shell, and the fuses.

THE GUN.

The gun barrel consists of a very light tube having, at present, a smooth bore. As the firing pressure used does not exceed 1000 pounds per square inch, it will be seen that, if made of steel or aluminum bronze, it need not be more than one half inch thick even in calibres as great as twenty inches; a greater thickness has been used in the 8-inch and 15-inch guns, for the purpose of obtaining somewhat greater rigidity and to lessen the chances of mechanical injury in transportation and manipulation. Where it is important to eliminate weight, as on shipboard or on torpedo boats, these tubes can be made very light indeed, especially in cases where they are placed at a fixed angle.

When the machine is to be movable for elevation or direction or both, the barrel is supported on a suitable truss.

The breech mechanism is ordinarily a simple gate arranged so that the valve mechanism cannot function until the breech is closed and latched.

THE VALVE.

The valve is known as a balanced valve, so arranged as to open and close by a single movement of the operator. The time of opening and closing can be varied by an adjusting device so that any desired loss of pressure will ensue. In this way the range can be changed without change either of elevation or pressure. In addition to this means of controlling the range, there is a device for throttling the passage-way between the valve and the reservoir of the gun, so that although the valve may open and close in a uniform time, the amount of air which can pass into the gun in that time can be varied. A more complete and accurate control of the range can be obtained in this way than in any other. The size of the passage-way can be quickly regulated to a hair's breadth. In the case of a vessel advancing or retreating from a target, the opening can be constantly changed to conform to the variations of range, much more quickly and accurately than can be accomplished by corresponding changes of elevation of a gun.

THE RESERVOIRS.

The air reservoirs used thus far consist of wrought iron lap-welded tubes of 12¾ inches and 16 inches outside diameter and from ½ to ¾ inch thick. These tubes are from 18 to 20 feet in length. The reservoir tubes from which the air for firing is directly drawn are

known as the "firing reservoirs." This reservoir will, as a rule, have five times the capacity of the bore of the gun. Experiments are under way with a view of producing very light reservoirs, both by wire-winding and by cold drawing of brass and steel.

It may be well to mention here that the pressure in the reservoir may be reduced by a single firing to any predetermined amount, the valve being adjustable to accomplish this automatically. The most economical results are obtained with the air acting expansively. A loss of 10 per cent to 12 per cent with a reservoir of 5 capacities of the gun bore is the maximum which can be used with any appreciable advantage.

Where it is desired to fire a large number of rounds with great rapidity, an auxiliary storage reservoir is used, into which the air is compressed ordinarily to twice the pressure to be used in the gun. After each discharge the air is drawn from these, to restore the pressure in the firing reservoir to any desired point.

THE COMPRESSORS.

The air compressors may be of any type capable of giving the high pressures to be used. We have used the compressors of the Norwalk Iron Company. These compressors perform the compression in two stages, there being an intermediate cooling in passing from the first compression to the last.

Where cooling processes are to be used for other purposes on shipboard, the air compressors can be utilized. They may also be of use where the pneumatic gun carriage system is introduced.

THE SHELL.

The shell is made at present of brass tubing and castings, made as light as consistent with the necessary strength for handling and in being fired. The shell is retained in its proper trajectory by means of the tail tube, to which are attached spiral vanes. It is centered in its passage through the bore and kept from metallic contact with the same by means of non-metallic pins in the head, the leather gas check at the rear end of the cylindrical part of the body, and by the vulcanized fibre projections riveted to the spiral vanes of the tail.

We have recently succeeded in making the conical point and cylindrical portion of the shell of a single seamless piece, it being produced by hydraulic pressure. This was not considered easy of accomplishment in view of the fact that, for the 15-inch shell, the

piece is 14¾ inches outside diameter, 80 inches in length, and ⅛ inch thick. The conical point is made strong enough to resist crushing from impact with water, but so thin as to readily crush when striking a solid target.

THE CHARGE.

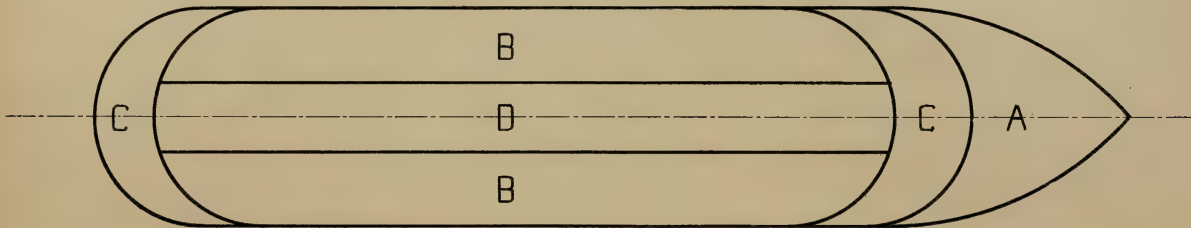
The charge used thus far has been uncamphorated explosive gelatine, having a core of dynamite. This core is for the purpose of producing a complete detonation of the less sensitive explosive gelatine. I would prefer, for this purpose, compressed dry gun-cotton, as cold weather does not affect its properties as a detonating substance. The arrangement of the charge is essentially as shown in the diagram.

At the front and rear of the charge I would use camphorated gelatine to increase the chances against explosion by shock both in starting the shell and in striking the target. For this purpose also, a diaphragm is placed so as to stop off the charge some distance from the point; this will give time for detonation of the charge from the *rear end* before the front can be exploded by shock. To guard still farther against the possibility of explosion by the impact and give time for the electrical primer to act, it may be necessary to place a cushion of felt or other elastic substance in front of the diaphragm. This can only be determined by actual experiment against armor plates.

I have preferred uncamphorated explosive gelatine because it gives the maximum explosive energy for specified volume of shell, both on account of its very great energy and its high specific gravity. The energy compared to dynamite No. 1 is as 142 is to 100, according to General Abbot and other authorities. Its specific gravity is 1.6 compared to 1.2 of dynamite No. 1 and 1.0 of gun-cotton. Thus, in a given volume of shell the explosive energy, where uncamphorated explosive gelatine is used, will be as 189 is to 100 when compared with the same volume of dynamite; compared with *dry* gun-cotton, it would be 263 to 100, or close on to 2⅝ times the explosive energy. If *wet* gun-cotton is to be used there is a strong probability of the relative strength being greater. I am aware that there is some question as to the relative strength of gun-cotton as given by General Abbot, but it is seen that a large margin is likely to remain in favor of the explosive gelatine.

It will undoubtedly rest with each branch of the service to select that explosive which seems to it safest and best. I merely mention

DIAGRAM OF ARRANGEMENT OF CHARGE



A = Empty space at point

BB = Uncamphorated gelatine

CC = Camphorated "

D = Guncotton or Dynamite core

my own reasons for having selected and used uncamphorated explosive gelatine. I have used this for more than two years, during which time I have fired more than one ton of gelatine made at the Nobel's Explosives Company's works near Glasgow. Besides use in the gun I have subjected it to various tests of alternations of heat and cold, as well as subjecting it to very severe shocks. I am satisfied from this experience that, if well made, it is not subject to deterioration whilst in store, or to explosion by shock if handled as carefully as gunpowder.

The only unfavorable thing that I have observed, and that but rarely, is a very minute exudation of nitroglycerine when thawed after freezing. I propose to meet this contingency by having the cartridges made up in discs having a central hole for the detonating disc of gun-cotton. These large discs are to be covered completely by a rather thick covering of asbestos paper or other absorbent material, having incorporated therewith an alkaline substance, such as carbonate of magnesia, so that any exudations of nitroglycerine will be absorbed by the covering, and any free acid which might be present or develop in the exuded nitroglycerine will be neutralized. Besides this, the thick non-conducting envelope will partly protect the explosive from great alternations of heat and cold.

In view of the advantages of the explosive gelatine and the improvements made in its manufacture, it will be well to make thorough tests therewith before definitely settling upon the exclusive use of gun-cotton. Whilst reliable explosive gelatine has thus far only been procurable from abroad, at least two of our reputable and experienced manufacturers of high explosives are prepared to manufacture the gelatine under the Nobel patents and processes.

THE FUSE.

The earliest experiments with the pneumatic gun demonstrated that the ordinary fuse arrangements were insufficient to obtain the best results with high explosives.

It was found necessary to produce the initial explosion at the *rear* end of the charge, to produce the maximum effect on a solid target.*

* I fired a shell charged with sand only, against a target of thin iron plates, and three were perforated. A shell charged with dynamite arranged so as to explode by impact from the front end was next fired, and only one plate was perforated. A shell charged as before, but arranged so as to explode from the rear end, was fired and six plates were perforated, that being all that constituted the target. Commander Folger's experiment also indicated the necessity of having the initial explosion at the rear end of the charge.

It was important, therefore, that this explosion should take place an instant *before* full impact.

To obtain the very important torpedo effect which is the primary object of the pneumatic torpedo shell, it was necessary to cause the explosion to take place an interval of time *after* striking the water. The tamping due to the submersion would give the maximum energy of the charge, and this against the more vulnerable under-water hull. Where countermining was to be attempted against ground mines, it was desirable to ensure some of the shells getting to or near the bottom before exploding. Above all, the fuse must be assuredly safe in storage and in handling. Consideration of these requirements has led to the development of the electrical fuse.

This consists of four parts:

1. The electrical battery;
2. The low tension primer;
3. The circuit breaker; and
4. The detonating cap.

The chloride of silver battery has been selected as being most suitable. Although the electro-motive force is low, the internal resistance of the battery, as made, is very low, and a small single element suffices to bring the bridge to a red heat. But to ensure against accidental increase of resistance in the circuits and to reduce the *time* required to fire the primer, one set of batteries is made quadruple, the other two sets are double. Each set is arranged in series. All of the elements of the quadruple battery, which is in the rear end of the shell, are wet with salt water before insertion into the shell. One pole of this battery is connected, through the primer embedded in the fulminate of mercury detonator, to the metallic body of the shell; the other pole is connected with a light copper cone fixed in the conical point of the shell and insulated therefrom. The shell striking any solid target, either normally or otherwise, will cause the outer shell to crush in on the insulated cone, close the wet battery circuit and explode the charge.

A double dry battery is placed in the point and another at the rear end. This last is inserted as a matter of precaution rather than as an absolute necessity. One element of each of these double dry batteries is wet up, and is ready for action as soon as the salt water enters the other element. Upon the shell entering the water, the dry element becomes wet, the current then passes through a primer which ignites a time train. This in turn ignites the detonator. The time train is

adjustable so that a variable submersion before explosion can be obtained. The rear dry battery acts in the same manner should the other fail. If it is desired to cause the shell to reach the bottom before exploding, a water cap is attached to the dry battery in the point of the shell. Provisions are made to protect the front and rear batteries from moisture until the shell has left the bore of the gun. If fighting in fresh water, a small bag of salt is placed in the dry battery fuse case.

The circuit breaking device ensures all circuits being retained open until the shell has left the bore of the gun. If anything should be amiss with the circuits, no explosion will result until the shell is some distance beyond the muzzle. Nothing can be amiss, however, if proper care is taken in making up the shell, arranging the circuits, and testing. The circuits can be tested at any time before inserting either the batteries, primers, or detonators; there need be no guess work as to the condition of the circuits at any time. The batteries, primers, and detonators need not be inserted until just before using. A double set of circuit breakers, primers, and detonators are used to increase certainty of action.

To guard against the chances of breaking the very fine filament of platinum wire constituting the wire bridge, it is embedded in a very solid cake of compressed gunpowder.

EFFECT OF EXPLOSION OF TORPEDO SHELL.

The torpedo shell has a double field of action, the over-water hull and the under-water hull.

There are very few, if any, complete experiments which will show just what very large charges of high explosives will effect, either against the armor or the general over-water structure of a ship. The elements of suitable tamping and proper method of explosion have been omitted. The Scandinavian experiments quoted by General Abbot, give as an approximate formula $W = 3.3d^2$, where $W =$ weight of Dynamite No. 1, $d =$ thickness of wrought iron armor. This will give a perforation, or rather breaking through, where uncamphorated explosive gelatine is used (taking this at 142 as compared to Dynamite No. 1 at 100), as follows:

55 pounds, . . .	4.8 inches	600 pounds, . . .	16.0 inches.
100 " . . .	6.6 "	700 " . . .	17.4 "
200 " . . .	9.3 "	1000 " . . .	20.4 "
400 " . . .	13.2 "		

It will appear from this that the decks of the most heavily armored ships will be vulnerable to the 8-inch torpedo shell charged with 100 pounds of explosive gelatine, and even the smaller shell will break through. The torpedo shell charged with 600 pounds will break through a very large proportion of the more heavily armored parts. The decks and lightly armored parts comprise a much larger proportion of the over-water target than the parts carrying more than 16 inches.

When exploding against the more heavily armored parts and failing to perforate, much damage will probably be incurred by the enormous transmitted shock. This will seek out the weaker parts and produce fractures at points some distance from the point of impact and explosion. Where the explosive energy is greater than the resistance offered by the target, the result is something greater than a mere perforation; there is a general breaking in of the surrounding parts of the structure. When striking a turret or casemate armored more heavily than the charge is able to break through, the very great shock produced by the explosion of a 600 pounds charge would be likely to place the personnel *hors de combat.*

Should it be considered advisable to make the over-water hull, in its heaviest armored parts, the objective point of attack for these torpedo shell, pneumatic tubes can be built to throw any sized charge that may be requisite for breaking through, even if experiments demonstrate that a shell containing one ton was required to perform the work.

But the work of attacking the over-water hull will be left to the high power powder guns. I have only endeavored to show that the torpedo shell is likely to produce much injury to the over-water hull, should it miss the real objective point, the under-water hull.

Regarding the effect of the explosions when occurring under water there appears to be less question, except as to the size of the charge. Until recently, less than one hundred pounds of gun-cotton have been considered sufficient. A natural sequence of the general use of auto-mobile torpedoes, such as the Whitehead, has been the strengthening of the under-water hull, and at the same time the increasing of the cellular subdivision. This renders larger charges desirable. The pneumatic torpedo gun system makes this perfectly feasible. It is simply necessary to establish the size of the charge to be thrown.

According to General Abbot, the explosion of 100 pounds of explosive gelatine under water would be effective against a first-class

war vessel at the distance of 21 feet. More recent experiments indicate that this distance is too great. Lieutenant-Colonel J. T. Bucknill, Royal Engineers, in a series of articles published in "Engineering," takes the danger radius of the same charge as being about 10 feet. This difference is partly due to the great strengthening and subdivision of the hull made necessary by the development of the automobile torpedo. Whilst General Abbot assumes a pressure of 6500 pounds per square inch as fatal, Colonel Bucknill assumes that nearly twice this is requisite.

The effective horizontal range of a 600 lbs. charge would probably be about 50 feet. If the explosion takes place at somewhat greater distance than this, although the result would not be fatal, there is very great chance of the steering gear and propellers being seriously injured and the vessel being rendered helpless to continue manœuvring. A shell striking say 100 feet from the target is likely to be within effective danger radius at the time when the explosion takes place, owing to the delayed action of the fuse.

ACCURACY OF FIRE.

The question as to whether the pneumatic torpedo gun can deliver accurate fire appears to be settled by the trial before the Naval Board in June, 1886, and the destruction of the Silliman on September 20, 1887. In the first case, four out of five shell landed in essentially the same spot at a range of 1613 yards; the other shell went about seven yards beyond. The lateral dispersion was slight. The destruction of the Silliman is too well known to you to require further description.

On September 30, 10 shell were fired for rapidity and grouping. I was requested not to make any allowance for the variable conditions of wind. The gun was set at zero although the wind was variable both in direction and force and I could have changed the direction of the gun whilst loading, without loss of time. The men I had could not be called trained men. Ten (10) shell were fired in 10 minutes and 45 seconds. Had the Silliman been anchored end on, the bow or stern being at the buoy taken as a target, two of these shell would have struck the vessel directly and four would have exploded near enough to have destroyed the ship. Two others would have injured her seriously by the explosion. Although this may be considered a fairly good record, I believe that even a greater percentage of effectiveness can be shown in future trials. It was the first time that I fired for rapidity. The trial developed the necessity

for having a somewhat larger connecting pipe between the storage and the firing reservoirs, as well as for a slight change in the arrangement of the pressure gauge. The firing pressures were not gauged as accurately as in less rapid firing, owing to defects which were not apparent in slow firing.

The question of accuracy on land is established, but the naval officer, bearing in mind the difficulties he meets with at sea in firing powder guns accurately, doubts the ability to obtain accuracy with the high angle fire of the pneumatic gun. The unknown range and unstable platform enter as factors of uncertainty. The flat trajectory of the powder gun does not require so accurate a knowledge of the range as is the case with the high angle fire of the pneumatic gun. To this I would answer that the latter has practically a larger target presented in having not only the large area of deck available, but also the considerable danger zone surrounding the ship.

It is conceded that the flatter trajectory of the high power powder gun gives it very important advantages as to increased danger space, but errors of angles of elevation due to the *rolling of the ship* may produce very marked changes as to the point of impact on the vertical target, which is almost the only one attainable by its fire, at short ranges; the errors of range as to the horizontal plane will also be considerable.

An error of angle of fire of the high power powder gun of only 15 minutes will throw its shell at a range of 1 mile about 23 feet above the point aimed at. The change in range will be, with the 8-inch rifle, about 230 yards, while with the same error of angle of fire of 15 minutes with the 15-inch gun of the dynamite gun cruiser it will be only 15 yards.

A system of range finding can be adapted to use on shipboard which, within the range of one mile, will give fair approximations. With the new throttling device which has been introduced, the range adjustment can be made to conform accurately and constantly to the change of range due to the advance or retreat of the ship or the target; no change will be required either as to elevation or pressure. The person operating the firing lever will have nothing to consider except the *line* of fire—when this is right he pulls the lever. Should the ship be pitching, the lever is retained by an automatic device until the gun is at the proper angle with the horizon. Should the ship be rolling at the time, he must cease pulling the firing lever until again approaching the vertical plane; allowance can be made as to the time

of passage of the shell in the bore, and here some skill and judgment on the part of the gunner will be demanded. It is true that the gun cannot be fired successfully at every instant, if the sea is rough. That objection applies also to other guns. Conditions are not always unfavorable in the harbor work for which these guns will be used chiefly. The rapidity of fire possible will also compensate somewhat for errors in judgment as to firing, by the increased return of opportunities. The guns mounted on the dynamite gun cruiser will be capable of being fired twice per minute.

As to the alleged slowness of flight of the shell and the probable displacement of the target during the time of flight, it might not be amiss to compare the velocity of the aerial torpedo with the best movable submarine torpedo, at present assumed to be the Whitehead.

Granting to the latter, for a range of 300 yards, a mean speed of 25 knots per hour, this would imply a velocity of about 42 feet per second. The mean horizontal velocity of a shell from the pneumatic gun at a range of one mile is about 580 feet, or about 14 times as great as that of the movable submarine torpedoes. This certainly is not an unfavorable showing as to relative speed. The enemy's ship, therefore, will not have moved as far during the time of flight of the torpedo from the pneumatic gun, through a distance of *one mile*, as during the passage of the submarine torpedo through a distance of 300 yards.

Again, the latter must make an absolute hit, while the former may be effective even when having missed the target by a good many feet. Of course, a skillful gunner will make allowance for the probable movement of the target during the time of flight, and accuracy of judgment in this case need not be so great as in the case of the submarine torpedo. Assuming that an enemy's ship, 300 feet in length, is moving at a speed of about 12 knots, it will have moved a little more than one-half of its own length during the time of flight of the shell for a range of one mile. If the ordinary movable submarine torpedo is discharged at its effective range of only 300 yards, the vessel will have moved more than once and one-half times its own length, or nearly three times as far. At a greater speed of the target than 12 knots the disparity of distances will be even greater. When the pneumatic gun is brought to closer quarters than one mile, the chances in favor of its torpedo are relatively greater.

It is said that in the use of submarine torpedoes exact knowledge of the range is not required. But unless used against a stationary

target this is not the case. Owing to its relatively slow speed, a close approximation of the enemy's range as well as speed of movement must be made, to make due allowance for the probable displacement of the target during the passage of the torpedo.

If delivering fire against the broadside of a ship, the submarine torpedo has as its margin one-half the length of the ship, as to its direction, but with the chances of the results of errors of judgment being increased by its long time of flight. The torpedo shell has the same margin as to its line of fire, increased, however, by some yards ahead and astern of the target and the very much shorter time of flight. In addition to this the latter has, for this case, a margin for error of range of certainly twice the width of the ship, the margin being greater in both directions where larger charges are thrown.

If the fire is delivered straight ahead, the submarine torpedo has a margin of only one half the width of the ship, well *below the water line.* The torpedo shell has practically a margin of the width of the ship as to its line of fire, owing to the danger zone when missing the direct hit. It has also a margin as to error of range of something more than the length of the ship.

Besides this, a vessel carrying the pneumatic torpedo gun can deliver fire directly ahead *whilst moving at full speed.* The torpedo boat using the submarine torpedo *must slow up very considerably* before attempting to deliver its fire straight ahead, if it is to avoid danger of running into its own torpedo.

I will continue the comparison of the torpedo shell of the pneumatic gun system with dirigible and auto-mobile submarine torpedoes.

The Whitehead torpedo, whilst having a possible range of 800 yards, can hardly be said to be very accurate even at 300 yards. Particularly is this the case when discharged from a vessel in motion, and very great fault has recently been found with this. It is subject in its flight to the varying and unseen eddies, currents, and waves. It must make an absolute hit to produce results. It may be stopped by booms and netting. It carries so small a charge that, even if in contact with the enemy's hull, doubts are expressed of its efficiency. Its speed at most is only 27 knots. It cannot therefore be used directly forward, by a vessel advancing to attack another by ramming, as it is in danger of running into the explosion of its own torpedo. It is relatively bulky and expensive; very few can well be carried, and each time one is used, a considerable proportion of this portion of the armament is thrown away. The following quotations from a recent number of the *Pall Mall Gazette* may be interesting:

"Moreover, in firing from the bow, the slightest twist at the immense rate of speed of the torpedo at the moment of leaving the boat would be enough to account for any eccentricities of behavior. More than one English officer has been startled by discovering his own torpedo looking him in the face."

The Lay-Patrick torpedo has a speed of 20 miles—weighs about 4000 pounds, carries a charge of 125 pounds, and costs about $8000 each. The Sims electrical torpedo has a speed of 11 miles, weighs about 4500 pounds, and carries a charge of 300 pounds; it costs about $7500. Of the Brennan torpedo, little of detail is known in the United States except that it, like the Sims and the Patrick, must be connected with the operating station by wires, and has been very severely criticised in England. In all of these a very long life artery is exposed to injury.

Two, if not all, of these three are expensive, and all are bulky, and relatively of no great speed. They must be seen the entire distance to be operated. This is a matter of no little difficulty at distances exceeding one half a mile, where there is any mist, smoke, or rough sea. If they can be seen by the operator for the distance of the maximum range (supposed to be two miles for the Sims torpedo), the chances are fair that the vessel to be attacked will discover the approach in time to evade the blow. It should be noted that the greatest speed claimed for this last class of torpedoes is less than that of the most recently constructed ships of war. All of the torpedoes mentioned can be stopped by booms and netting. The Whitehead torpedo must make an absolute hit.

In contrast to this, the torpedo shell of the pneumatic gun has a number of important advantages. The proportion of weight of the shell compared to the charge is relatively small. To put this in another way, the proportion of the charge is very great compared to the weight of the shell. They are comparatively light, compact, and inexpensive. A larger number of rounds can be carried. They have a field of action against the over-water hull as well as against the submerged parts. They may be effective without making absolute hits. Neither booms nor nettings can stop them. Their mean horizontal velocity for a range of two miles is about 300 knots, as against the maximum velocity of 27 knots recently claimed for the Whitehead, and the very much less speed of the others mentioned. The attainable range is very much greater.

I do not wish to be understood that there are not many situations

where I deem these submerged movable torpedoes to be of value. I would have some of these torpedoes as a portion of the armament.

I have been obliged to present the case of the aerial torpedo shell in this way, as compared to the submerged movable torpedoes, because the latter have been accepted in foreign services, and the former have been, until recently, looked upon with doubt.

It is gratifying to know that in lieu of the inefficient Whitehead torpedo we have an American invention which promises to be very much superior thereto in every essential respect. I refer to the Howell torpedo, invented by Captain John A. Howell, U. S. N. Whilst having some of the limitations mentioned, it is capable of attaining greater accuracy at *close quarters* than is possible with the Whitehead, and is less bulky and expensive.

Before proceeding to the question of the naval uses of the pneumatic torpedo gun system, I will discuss two points which are frequently suggested.

RIFLING.

To the professional mind it naturally occurs that it would be well to resort to rifling, dispensing with the long and cumbersome tail. To rifle a projectile so long and so low in density as the one in use would involve an exceedingly rapid twist. According to Professor Greenhill's formula, a twist of one in thirteen is required for a cast-iron shell 8 calibres in length. This will be about the average length of the dynamite shell without the tail; it being, however, somewhat shorter in the larger calibres. The density of the charged shell will be much less than that of the common iron shell; hence it is probable that a twist of about one in eleven will be required. To impart so sharp a twist will put a very considerable torsional strain on the thin wall of the shell, as also on the (proportionately) equally thin walls of the gun. Again, the explosive will have to sustain an additional shock due to the very high angular velocity imparted to the shell. There is very great danger from the heat which will be generated in the friction of the projectile whilst being forced through the gun bore.

Whilst, as an artillerist, my natural predilections were for rifling, consideration of the foregoing facts led me to make haste slowly in this direction. I had constantly before me the experience gained at the proving ground at Sandy Hook and in foreign services, where the usual result of the experiments of firing the high explosives from rifled powder guns was a final dissolution of the gun.

Consideration of the matter has led me to see a number of ways by which some of the difficulties I mentioned may possibly be overcome. I have now a 2-inch rifle gun in which I shall test the matter even to the final bursting of the gun, establishing by my experiments, if possible, the limits to which the rifling can be used with safety.

USE OF GUNPOWDER FOR PROPULSION.

The feasibility of using gunpowder for the propulsion of shell charged with high explosives is continually broached. It has been frequently tried, but *invariably with final disastrous results* where the experiments have been carried up to moderately large charges. By *large* charges I refer to shell charges of not less than 50 pounds and reaching up to 1000 pounds, and even to shell charged with a ton of high explosive.

The advocates, or rather the predictors, of the use of high explosives from powder guns also demand penetration before explosion.

If large charges are to be thrown, the shell must necessarily be made thinner, and it is very doubtful if it will then withstand the concentrated blow it receives upon striking the target so as to penetrate even a moderate thickness of armor. The battering shell of the 100-ton gun contains a bursting charge of only 25 pounds of gunpowder. It would seem that the walls of the shell would have been made as thin as consistent with ability to perforate armor without breaking up.

Assuming that 25 pounds of a high explosive could be substituted for the gunpowder, it is very doubtful if it could be carried through heavy armor successfully before explosion. There is no record of large battering shell fully charged with *gunpowder* having perforated armor over six inches in thickness, without explosion until after perforation. On the contrary, explosion takes place prematurely, almost immediately upon impact, with the result of less injury to the target than that produced by an uncharged shell.

Much more surely will this be the case if a high explosive be substituted for the gunpowder as the bursting charge, unless the shell cavity is well cushioned. To do this involves reduction of explosive capacity. The energy available, after breaking up the very thick and tough walls of steel shell, will be but little greater than that produced by the gunpowder. The effect as to material injury or man-killing power will not much exceed that producible by the shell charged with gunpowder.

In firing a shell from a powder gun, the walls of the shell must necessarily be sufficiently strong to withstand the initial shock. This limits somewhat the capacity for bursting charge, even where armor piercing is not sought for. If a high explosive is used, some cushioning device is requisite, and a further reduction of capacity ensues.

Assuming that a shell charged with some of the high explosives can be thrown with safety from a powder gun under normal conditions of pressure, it is known that abnormal pressures, varying therefrom as much as from 5000 to 12,000 pounds per square inch, are not infrequent. This may be looked for especially when the gun is warmed by continuous firing. In addition to this the shell and the contained charges may become warmed by remaining in the hot gun bore some little time before being fired. The high explosives increase very rapidly in sensitiveness by slight increments of heat. If, then, with this condition of increased sensitiveness we have in addition an abnormal pressure, a premature explosion is very likely to occur.

In rapid firing of powder guns, when shell or shrapnel charged with powder are used, premature explosions of the shell are not infrequent. Much more will this be the case when the bursting charge is one of the high explosives.

In this connection another matter is to be considered. It is well known that the high explosives are capable of producing more or less violent explosions, depending upon the character of the initial shock or detonation. The more insensitive the explosive, the more powerful must be the detonating charge, to produce an explosion of the first order. Fulminate of mercury appears to be requisite in all cases. But fulminate of mercury is even more sensitive to shock than either ordinary dynamite or dry gun-cotton, hence the resulting shock must be tempered so as not to explode the more sensitive *detonating* charge rather than the specially insensitive *bursting* charge. Wet gun-cotton has been substituted for powder charges, but being quite wet reduces its explosive ability nearly to a par with gunpowder. Particularly is this the case where no detonating charge of dry gun cotton and fulminate of mercury is used. Where the explosion takes place by simple impact, not alone is it of a low order, but as the initial point of explosion is from the front, the resulting injury to the target is less than from a blank shell. This was exemplified in some experiments made at the Naval Proving Ground by Commander Folger, U. S. Navy.

From his experiments Commander Folger arrived at the following

conclusions, in some respects similar to those above stated. These are as follows:

(*a*) Using a weak shell charged with the high explosives, no material injury would result to the over-water defense of a modern armorclad, even with gunpowder as the propulsive force and using greatly increased bursting charges. The effects, *nil* with low velocities, will be equally valueless with high velocities.

(*b*) It is believed that using a strong walled *steel* projectile, the explosion occurring at impact at an elevation of temperature of less than 300° F., the effects will be less notable than with similar projectiles charged with gunpowder.

This last conclusion has been confirmed by recent experiments at Sandy Hook. After firing the Smolianoff shell charged with diluted nitro-glycerine, a shell charged with gunpowder was fired from the same gun at the same target. The gunpowder shell produced the greater injury.

In the experiments from which these deductions were made the explosions were of a low order, being produced by simple impact from the front end. The importance of having the initial point of explosion in the rear has been already noted. Commander Folger quotes other experiments where the explosion of discs of gun-cotton on iron plates gave very markedly increased results when the initial explosion was on the side farthest from the plates. By the pneumatic gun system, full detonations can be produced, evolving the maximum energy of the explosives used; the initial detonation can be assured to take place from the *rear* end, producing the maximum injury of the target.

Where very large charges are to be used, the electrical primer enables us to have a number of centres of simultaneous ignition, should this be found necessary. The possibility of this being required is mentioned by Commander Folger, but he cites no concrete experiments upon which he bases his opinion.

NAVAL USES OF THE TORPEDO GUN.

Torpedo Boats.—The gun can be used advantageously on board of torpedo boats in lieu of ordinary movable torpedoes, or in conjunction therewith; some of the advantages, compared with the latter, have already been stated.

To get in the shot at all effectively, if equipped only with the ordinary torpedo, the boats must approach so near that discovery is

inevitable, and the chances of escaping the fire of machine and rapid firing guns are comparatively slight.

The dangers to the torpedo boat may well be deemed to be inversely as the square of the distance, and a boat which approaches to, say, 352 yards (one fifth of a mile), will have one twenty-fifth of the chance to escape the enemy's fire, and to get in its own fire, possessed by a torpedo boat carrying pneumatic guns capable of firing the aerial torpedo a distance of one mile.

The objection is raised that the long tube of the pneumatic gun will be difficult to manipulate accurately and quickly whilst in motion. Recent experiments have enabled us to produce the same results with much shorter barrels, more easily manipulated on shipboard. The dynamite-gun-cruiser guns have been shortened from a length of 70 feet down to 55 feet. A 15-inch gun for land service is now building which is only 32 calibres in length.

Besides this, the peculiar character of the valve arrangement makes it unnecessary to change the elevation constantly, although it is purposed to make this adjustable when required.

It is urged that the thin gun barrels will be easily injured by the fire of the enemy's machine and rapid firing guns—that there is very great danger of exploding the shell whilst still in the muzzle. Foreign torpedo boats for the Whitehead torpedoes have over-water discharge tubes. These are even more liable to injury from the same kind of fire, and the torpedoes may be exploded before being ejected, as they must approach much nearer to the enemy. It is difficult indeed to carry on operations of war without some danger to the combatants. The striking by the enemy's fire of the very much exposed over-water discharge tube of the Whitehead torpedo, before it is brought in action, will be quite as disastrous as the explosion of the aerial torpedo shell at the instant that it is leaving the muzzle. The pneumatic torpedo tube may be so placed as to bring the greater part of its length below the deck. The breech section containing the shell is below the water line, and can be further protected by coal and armoring such as protective decks, etc. Should it be considered desirable to use the gun at lower elevation, more protection might be afforded in heavier plating of the decks and semi-casemates or hoods directly over the guns. The muzzle part which projects above the decks can be made very thick, and may be protected by movable hoods or shields. Thus, very fair protection can be given both to the tube and to the torpedo, except at the instant of firing.

Although greater weight will be demanded for the pneumatic torpedo gun than for the ordinary torpedo appliances, it is thought that the advantages of greater attainable range, greater charges, and more accuracy will compensate for this disadvantage. The small weight and bulk of the torpedo shell aid to balance the greater weight of the gun, etc. A larger number of torpedo shell can be carried.

The loss of speed is compensated for by the longer range of effective action than that possessed by the ordinary torpedo. But if we consider the combined speed of the vessel and its torpedo, a very wide margin is left for the pneumatic torpedo gun vessel.

USE FOR DEFENSE OF SHIPS AGAINST TORPEDO BOATS, DIRIGIBLE TORPEDOES, AND SUBMARINE BOATS.

The present *active* defense of a man-of-war against torpedo boats is dependent on absolutely hitting a *small* and rapidly moving object. This is somewhat difficult of attainment with the shell from the pneumatic gun, but an absolute hit is not required. The hulls of torpedo boats built thus far are so slight that a pressure of, say, 1000 pounds per square inch would be enough to disable them, if not absolutely to disrupt them. A shell with 100 pounds charge will effectively *stop* the approach of the enemy's torpedo boats before they can discharge their Whitehead torpedoes, even when the explosion takes place at a distance of more than 50 feet from the boat, if General Abbot's formulae are correct.

Again, should the enemy's torpedo boats succeed in discharging their under-water movable torpedoes (such as the Whitehead), the present armament of a man-of-war is incapable of stopping them in the least, unless the wire protective nettings are down. This is not always the case. The prompt use of a small pneumatic rapid-firing gun would be effective in this direction, as its shell would burst under water, and have a large effective radius in a field where the ordinary powder gun projectiles cannot be effective.

Dirigible torpedoes such as the Lay-Haight, Patrick, Sims, and Brennan, can also be stopped by this means. Besides the possibility of injury to the hulls of these torpedoes and the delicate machinery contained, all of these may be rendered innocuous by injury to the long wire on which they are dependent for manipulation and life. A pneumatic gun of comparatively small calibre, as dirigible as the rapid-firing Hotchkiss, could be designed for this purpose.

Submarine boats will doubtless be important factors in future naval operations and combats. Their presence and approach may sometimes be detected by bubbles and other indications. In the experiments already made with the Nordenfeldt submarine boat, it was so far submerged that no part of the ordinary armament of a man-of-war could have stopped it in its approach and attack, and it could easily have taken up a position within 300 yards, at which distance it could discharge its Whitehead torpedoes with some approach to accuracy.

But a vessel armed with pneumatic guns could send its shell into the water over or in the vicinity of the attacking submarine boat. The explosion being regulated to take place when the shell was completely submerged, would inevitably end the career of this submarine boat.

USE AS AN ADJUNCT TO SHIPS RAMMING.

It is held by naval officers that ships will use the ram in the course of naval combats. Granting this, a modification of the pneumatic gun can be introduced into a ship, of such form as to be but very little in the way. In case of ramming being undertaken it would serve as a most valuable adjunct, and might be said to be equivalent to extending the length of the ram from 500 to 800 yards.

This could be done by placing in the bow of the ship a tube about forty feet in length and, say, twenty inches in diameter. The gun may be placed parallel to the keel, and at a permanent angle of elevation of a few degrees. The tube may be fixed, the muzzle coming out at the bow a little above the water line. The muzzle should, of course, be protected by a suitable movable shield. The body of the gun, especially that part in which the charge is placed (the breech), being well below the water line, is sufficiently protected. The bow ordinarily is very little subject to being hit. A 20-inch shell could contain about 1000 pounds of gelatine, equivalent to 1420 pounds of dynamite. With a pressure not exceeding 500 pounds it could be sent at least 800 yards in advance of the ship, it being assumed that she is steering directly upon the enemy. Should there be a direct hit of the enemy's hull above water, there can be no doubt as to the result of the detonation of this enormous mass of explosive. The additional weight demanded by adding such a tube to the armament would be small compared to the results attainable.

COUNTERMINING.

Besides the direct aggressive action against an enemy's ship, I would call special attention to the great utility of a tube fixed in the

bow for countermining an enemy's line of stationary torpedo defenses. Not alone will they be effective against the ground and floating mines operated from shore stations, but the operating cables are very likely to be cut, and entire groups rendered innocuous. Besides this, all mechanical acting mines will be destroyed within a very large radius of the countermining explosion. Shells with smaller charges can be used for this purpose. Officers of experience deem this a very important feature, possessed by no other appliance.

TORPEDO RAMS.

Besides various classes of torpedo boats and torpedo cruisers, England has established a class called the "torpedo rams," the Polyphemus being the first of the class. Her armament consists essentially of rapid firing and machine guns and Whitehead torpedoes.

To fulfill the most important part of the work for which the Polyphemus is designed implies an approach of from 300 yards, down to an absolute contact with the enemy. A vessel smaller than the Polyphemus could carry two 17½-inch pneumatic guns, capable of throwing with accuracy charges of 700 pounds of explosive gelatine to a range of at least one mile. This charge is equivalent to about 1100 pounds of dry gun-cotton, or more than ten times the charge of the Whitehead torpedo. Considering this, and the greater range and accuracy attainable, the relative value of vessels armed as the Polyphemus now is, and as one of her class might be (with pneumatic guns), seems to be very much greater in the last case than the first. There is nothing to preclude the partial armament of the vessel with submerged torpedoes should it be deemed advisable for work at close quarters.

A vessel of about 1500 tons displacement belonging to this type could carry two 17½-inch guns. One of these guns could be arranged to fire to the front, the other to the rear. The front gun can be made to train 22° on either side of the medial line, and could have a range of at least one mile. The rear gun can have a train of 360°. It is assumed that vessels of this type are to be aggressive in character, and the disposition of the guns made accordingly.

A vessel so armed could, in retreat, or when manœuvring near an enemy, make its power felt and do effective work even when assailed on all sides.

The vessel would have preferably a low freeboard, presenting a small target to the enemy's fire; the decks and sides could be quite heavily armored so as to resist the rapid firing guns.

Special thick shields could be so placed forward as to protect the gun rooms when moving to attack. With the armor and full utilization of coal protection, as well as an extreme cellular subdivision of the bottom and hull, and very large pumping capacity, she might advance to the attack of the most heavily armored vessel afloat, with far greater chances of success than other torpedo boats, rams, or even larger vessels. The speed of such a vessel should not be less than 18 knots. She should have a very large armament of rapid firing guns and revolving cannon, so that her advance would be heralded by a stinging cloud of missiles, disconcerting the accuracy of aim of the enemy's gunners as well as enabling an efficient defense against torpedo boats.

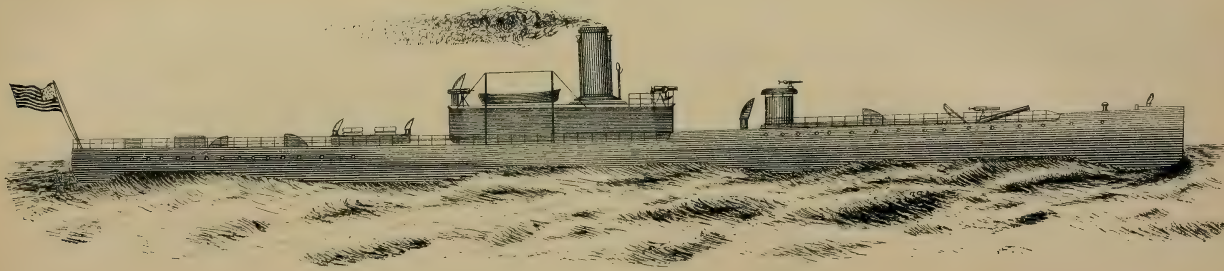
As the function of this class of vessels would be for harbor and sea-coast defense, neither a large crew nor a very large quantity of general supplies or coal need be carried. Hence fully 20 per cent of armor could be carried. Having a low freeboard, the weight of her hull could be relatively greater—*i. e.* more weight could be disposed of in subdividing the vessel into a very large number of cellular compartments.

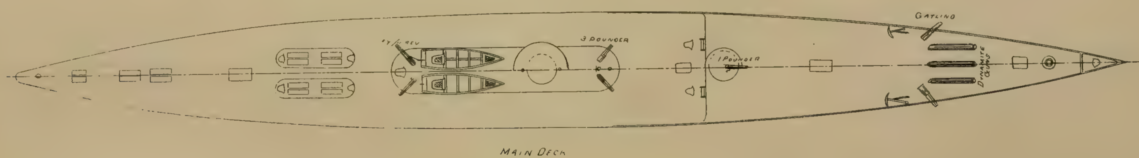
THE DYNAMITE GUN CRUISER.

This vessel, now building for the United States, will have three guns of 15-inch calibre. These are placed abreast and parallel at a fixed angle of 16°, the muzzles projecting through the deck at about 37 feet from the bow. The range of these guns will be at least one mile. The full calibre shell will carry 600 pounds explosive gelatine, equivalent to 852 pounds of dynamite No. 1 or to 943 pounds of gun-cotton. Shell containing smaller charges can also be thrown by the system of sub-calibre recently developed. The speed will be at least 20 knots.

The speed of 20 knots is exceeded by the small and very light torpedo boats built abroad, but the hull of this vessel will be sufficiently strong to be serviceable in rough water, which is not the case with the more lightly built torpedo boats. The training of the gun is given by steering the vessel. The range will be varied by the valve arrangement previously referred to.

The vessel has twin screws and steam steering gear. The arrangements will be such that the guns can be fired from the conning tower. The shell are handled by hydraulic machinery throughout the loading, so there is no danger in the manipulation in a sea-way. The guns can be loaded two times per minute. 30 full calibre shell can be carried.





DYNAMITE-GUN CRUISER.

Length over all, 252 feet 4 inches. Beam, 26 feet 5 inches. Displacement, 725 tons. Mean draught, 9 feet. Motive power, two triple expansion engines, developing about 3200 I. H. P.

Armament, three 15-inch Pneumatic Torpedo Guns, two 3-pounder and one 1-pounder rifles, two 37-mm. revolving cannon, and two Gatling guns.

It will be seen that this vessel is likely to be very well under control and will probably prove itself a formidable auxiliary war vessel.

CONCLUSION.

Owing to the unknown character of the pneumatic gun, its possibilities are not generally recognized, and many professional men have been loth to accept it as a practical appliance of war. It is considered by many as a species of quack medicine, as a toy—a pop-gun. I have therefore been constrained to argue the case in laying before you my views as to its applicability to naval uses, basing my arguments chiefly on accomplished facts.

I have pushed this work on as vigorously as I could, because, aside from the professional interest involved, I saw in it possibilities of usefulness in cases of public emergencies which may arise even now, before a regular modern armament could be provided.

Whilst I have never considered it as all-sufficient for defensive purposes, I have thought it a very valuable auxiliary in any event. But most of all, if attacked before modern guns, ships, and forts are provided, we could at least very seriously injure any attacking force before being ourselves destroyed. Our sting will be felt, and an attack will not be made with absolute impunity. The power that we have to inflict *some* injury will not be without weight in considering the advisability of attacking us.

No small element in considering the effectiveness of this weapon will doubtless be the moral effect. The knowledge that escape is not assured when the enemy's missile has failed to make a direct hit, and that the danger may even be *enhanced* by that miss, will not have a reassuring effect on the crew of the vessel attacked.

Absolute infallibility of successful action with each missile from this weapon can no more be assured than with those from the best of modern powder guns under the most favorable circumstances. As I have before said, skill and nerve on the part of the manipulator is as requisite with this as with other war appliances. It is for this that we require highly trained and skillful naval officers. But we have seen that the *probabilities* of attaining desired results are certainly greater than with any other torpedo appliance.

In making an attack of any kind, reliance is not usually put upon the probability of producing successful results with a single shot or torpedo. The chances are increased by increasing the number of guns used or torpedoes projected. For a given weight to be carried,

or for a given amount to be expended (looking at it simply from a commercial point of view), a very much larger number of torpedoes of the pneumatic gun type can be utilized than of any other having any approach to relative effectiveness.

I ask your assistance, by your criticisms and advice, to make this weapon practically useful for naval purposes.

DISCUSSION.

Rear-Admiral E. SIMPSON.—There is no doubt that our thanks are due to Captain Zalinski for the able manner in which he has presented to us the subject of the pneumatic gun, and for the separation that he indicates between it and other artillery weapons. He distinctly styles the weapon a "torpedo projecting machine," and claims for it "advantages over the torpedo appliances ordinarily in use." He also says, in explanation of his interest in it, that he "saw in it possibilities of usefulness in cases of public emergencies which may arise even now, before a regular modern armament could be provided." He gives as his opinion, however, that it may be made a valuable auxiliary to modern armaments, and asks for criticism and advice to "make this weapon practically useful for naval purposes."

When we contemplate the whole apparatus of the gun and carriage, with its air reservoirs, its firing reservoirs, auxiliary storage reservoir, and its air compressors, it is evident that the requisite appliances cannot be accommodated on board of any vessel of war as at present constructed; it follows that the adoption of such a system requires the construction of a portion of the Navy for the sole purpose of applying this weapon. The question then arises, is this weapon so important, and do we so need it, as to make this effort to adopt it justifiable?

The object to be achieved by the gun is to convey large charges of an explosive to the deck of the enemy, or to a point in close proximity to the unarmored bottom of the enemy's ship, where it is made to explode. For a gun, the range is very limited, and it seems almost impossible to assign the piece to any position in the defense of a harbor, except that of the torpedo. In resisting an attack from an enemy's fleet, the first arm to be brought into use is the large rifled mortar, this to be followed by the armor-piercing guns, supplemented by mortar firing with small charges as the enemy draws close to the works. The pneumatic gun might be a useful auxiliary at this stage of the action on shore, if it be screened from the effect of rapid-firing guns of the fleet which, at this time, would be brought into action; this precaution is indispensable, as the gun with all its details is very vulnerable. If used afloat to assist the defense, its time for operation will be during the interval between the passage of the forts by the enemy and the attack made on him by the torpedo boats, as its ranges of fire would enable it to cover the ground in advance of the squadron of boats, and by its moral effect (if no other were produced) would create a

favorable diversion in favor of the boat attack. This interval is of short duration, it is the critical moment when the failure of artillery defense points the time for the desperate alternative which abandons all considerations of protection and takes all risks. Up to this time the pneumatic gun is useless in defense; at this moment it may come into play as an advanced torpedo attack, and as a torpedo projecting machine might be assigned a place as an auxiliary in defense.

I am at a loss, however, to perceive any place to which can be assigned the pneumatic gun for naval purposes at sea. In that field it must be referred to another standard of comparison, and must be viewed in contrast with the gun. The comparatively short range renders the vessel bearing it liable to destruction long before it can come within the range of its gun; and even if within range, the uncertainty of the distance would make a hit a miracle, as the mortar-like character of the fire makes the objective point a point in fact; and however accurately may have been determined the point of fall (by equalizing pressures in the gun during successive discharges) when the distance is absolutely known, it is simply impossible to control this when distances are uncertain at best and constantly varying. No range finder can give the distance sufficiently accurate for this kind of fire, and, even if it could, the interval between the finding of the range and the discharge of the piece would vitiate the perfect working of the system, even in a smooth sea. The idea of conveying large amounts of an explosive to close proximity to an object, and utilizing its power to destroy the structure, is a most important one; but the great angle of fall indispensable from the use of a gentle force of projection does not inspire confidence in the chance of placing the projectile at the desired point. The pneumatic gun is simply a means proposed to accomplish an object which all allow is most desirable: may it not be that other means can be found to work to better advantage which will give a wider margin for successful hits?

In order to increase the chances of hitting, the projectile needs a more powerful force of projection, so that it may strike the water *before* reaching the object with considerable *vis viva* remaining in it; the effect of the fall will be (at any angle less than 45°) to change the downward motion to a horizontal motion of translation. It is supposed that the projectile is of such form as is described in the paper before us, and that the forward end is conical or semi-spherical in shape, and that the weight of the projectile be about that of the water it displaces. The distance that the projectile will traverse is, of course, due to the power remaining in it to overcome the resistance of the water; this must be provided by a more forcible agent than the pneumatic gun. This plan is the one proposed by Captain John Ericsson, and it offers better chances of hitting than where the effect is limited to the point of fall in what is termed *direct fire;* but Captain Ericsson, though he uses gunpowder as his projecting agent, limits himself to a small charge, and expects to deliver his fire at comparatively close quarters, much less than is proposed by the advocates of the pneumatic gun.

Now, in comparing these two systems, we have with the one a comparatively long range with small chance of hitting, and with the other a close range with

a fair chance of hitting. With one the flight is in the air until the object is reached; with the other the first portion of the flight is in air, the final passage being in the water. In either case the requisite to increase its efficiency is projecting power, so that the blow can be delivered from a longer distance, and this can be added in the case of the gunpowder gun to any extent that can be endured by the explosive in the shell; and if an explosive can be found that will endure the shock of a heavy charge of gunpowder, the occupation of the pneumatic gun is gone—it only exists by virtue of the sensitiveness of the high explosive.

This brings us to the consideration of the explosive itself. I recognize Captain Zalinski as an able expert on this matter, and I have no opinion of my own to advance in opposition to his selection of explosive gelatine. In making this selection, we are told in the paper that it is made in consequence of its giving the maximum explosive energy for specified volume of shell, and its absolute energy as compared with other explosives is vouched for by quotations from General Abbot, than whom no authority is better in the United States; but with this explosive we find ourselves limited, in the direction of propulsive power, to the pneumatic gun, or to a small gunpowder charge in the case of Captain Ericsson. Now, with all my respect for the opinion of the experts in explosives whom I have named, I cannot get away from the fact that the shells of the French Government, representing a nation armed and expectant of immediate war, are this day lying in their arsenals, filled with mellinite. These are to be used in guns to be fired with high charges of powder, probably for siege purposes against Metz and Strasburg. The components of mellinite are, I believe, not known out of France; yet, with the knowledge that we have of the ability of French artillerists, we cannot believe that such a step as this has been taken without absolute justification; nor can we, in the face of this fact, assume that the development of explosives has reached its climax in explosive gelatine, and proceed to shape our batteries accordingly. We are asked to do so by adopting the pneumatic gun, the existence of which rests on the sensitiveness of high explosives as thus far developed to our ken; we should await farther information before committing ourselves. The question is not properly stated when it is limited to the propulsion of a shell loaded with such explosive as we are cognizant of—that is letting "the tail wag the dog"; the question is so to solve the problem of explosives as to provide a powerful destructive agent which is not too sensitive to admit of being projected to great distances with high velocity.

The fact of firing the shell with a high velocity will modify the system proposed still farther by demanding a sufficient thickness of wall to resist the shock of discharge; but this need not be increased to the thickness required for penetration; the idea of penetration is not entertained in connection with the plan. For the same total weight of projectile the thicker wall will reduce the enclosed charge of explosive, and the effect will be correspondingly reduced; but the extracts in the paper, taken from lists of experiments made to show the effect of under-water explosion, show that the effect of a reduced charge may accomplish all the injury required, particularly if, by the Ericsson plan, we secure a hit, giving an explosion when in contact.

The part of the system proposed by Captain Zalinski that has come to stay is the fuze, which, without doubt, is an important contribution to artillery properties; this, with the determining the initial explosion at the rear of the charge, makes this part of the arrangement as perfect as can be.

Captain Zalinski frankly asks for criticism, and I submit these remarks in no spirit of mere fault-finding, but rather as a counsellor. As a naval artillerist I find it an effort to reconcile myself to the details of the system. I revert to the original cause which calls for this effort, and I see that if the cause be removed there remains no demand for such an expedient as is here proposed. Captain Zalinski is acting on the supposition that the character of the explosive is fixed, that it is to be regarded as a constant, and he adapts his means to this standard. I am not willing to accept the premise that leads to such a conclusion without farther proof of its accuracy, and having in mind the acts of the French Government already cited, I must declare myself skeptical as to the correctness of the premise. Captain Zalinski is to be allowed farther opportunities to develop the pneumatic gun, and its "possibilities of usefulness in cases of public emergencies before a regular modern armament could be provided" may be made sufficiently apparent to procure for the gun an assignment to a place for defense on shore, but I do not see the way to "make this weapon practically useful for naval purposes" at sea.

Brigadier-General HENRY L. ABBOT, U. S. A.—Captain Zalinski lays stress upon the fact that in his opinion the pneumatic gun cannot supersede artillery in maritime warfare. In this, I imagine, most professional men will concur; but after the statement of merits claimed for it, as set forth in this paper, I fear non-professional readers may incline to the opinion that, while an artillery officer may be pardoned for a little conservatism in favor of his own branch of the service, the legislator from his broader point of view may safely ignore the limitation. The safety of our coastwise cities has been imperiled from a similar mistake in respect to torpedoes, in spite of every effort of competent judges to the contrary; and I therefore think it well that this paper should be accompanied by the suggestion that perhaps the enthusiasm which has led Captain Zalinski to aid so powerfully in developing this invention may somewhat bias his judgment in its favor.

As to the merits of the pneumatic gun for naval uses I will only venture one remark. There is much in a name. We involuntarily associate with a "gun" the idea of a flat trajectory and high velocity of flight. Would not "pneumatic mortar" convey a more correct idea of this device? Modern rifled mortars yield surprising precision of fire when used from a stable platform on land. Has any authority proposed to mount them on shipboard? I believe it to be generally considered that a better platform than a rolling deck, and a more accurate traverse than can be given by twin screws, are needful to regulate vertical fire. Fortunately it will not be long before this matter will be tested, and it is wise to reserve judgment for the present.

As to the merits of the pneumatic gun for land use in coast defense, perhaps more definite inferences are warranted. To me it appears difficult to assign

any important duty to this invention. It cannot replace the fixed mines now used to obstruct the whole channel within a range of two or three miles from the forts, because it is as impotent as artillery to prevent the passage of ships when shrouded in darkness or fog. It cannot, from the nature of its trajectory, supersede the horizontal fire of shrapnel and of machine guns, upon which we depend to sweep the water surface and drive off launches attempting to countermine by night. Its range is too short to permit it to take the place of heavy guns in battling with armored ships to prevent them from destroying the land defenses of the obstructed channel. It cannot replace movable torpedoes directed from the shore, because they can operate among the mines and attack armored counterminers without endangering the submarine defenses; while the projectiles of this gun would actively aid the enemy and play the traitor among our mines. In one word, its short range restricts its fire within the usual limits of the mined zone; and its role in the defense of our harbors must therefore, in my judgment, be one of very minor importance. We cannot make much use of a weapon that directly antagonizes an essential element of our system whose duty it is powerless to perform. Hence it is as a naval weapon that I regard the pneumatic gun as probably having the best chance of success.

This paper treats of two distinct inventions, the pneumatic gun and the fuze. The former bases its claims for adoption upon the ground that it can fire charges of modern high explosives with safety, while powder guns cannot do so. But even now it is reported that 110-pound charges of wet gun-cotton are safely fired from 12-inch mortars in Germany, and new discoveries in the composition of explosives, adapting them for use in shells, are constantly making. It will probably not be long before all the advantages of projectiles charged with high explosives can be had without introducing a special pneumatic mortar for the purpose. Captain Zalinski's fuze, in my judgment, is quite a different matter. If further experiments confirm the results already obtained, this appears to be a contribution for which both Army and Navy may have uses. The device is not restricted to pneumatic guns and there is now much need of improvement in its field.

Lieutenant-Commander F. M. Barber.—*Gentlemen:*—The subject which has been presented to us in this paper is, I think, one of the most important that has occupied the attention of the Institute since Mr. Dorsey's paper on steel. It possesses an importance far beyond the particular methods and views presented by Captain Zalinski, from the fact that it brings us face to face with the very disagreeable fact that the long dreaded high explosive aerial projectile has arrived and it has come to stay. That somebody would ultimately find a way of throwing high explosives that are popularly supposed to be as dangerous to friends as foes, few have doubted; but I do not think that many of us would have been seriously annoyed if he had not appeared during our day. Here he is, however, and whether he has a wind gun or a powder gun or a squirt gun does not alter the fact that we must take hold of the subject and wrestle with it until we find what kind of a motive power and

what kind of a gun and what kind of a high explosive is best adapted to naval purposes.

Most Navy and Army officers have the idea that the ordinary powder gun is certain to be ultimately successful in using high explosives, and when Captain Zalinski appeared a couple of years ago with his unwieldy air gun there was a most extraordinary unanimity of opinion among naval officers that the windy experiment might do for the Army but not for the Navy, while in the Army it was thought that there was far more use for it in a ship than in a fort. However this may be, we are now presented with the fact that there is building for the Government a boat containing three of these guns.

The lecturer has very ably set forth their advantages, and has given us a large fund of information appropriate to the subject, thus opening up a large field for controversy, but it appears to me that the proper portion of his lecture for discussion and criticism on our part is this gun as it is now applied, and its chances of carrying out the idea of its designers, viz. to throw safely a large charge of high explosive, to throw it better than powder, and to throw it a distance of one mile with accuracy.

In the first place let us take the consideration of safety. Compressed air is used, and up to this time, in the course of the experiments with the 8-inch gun at Fort Lafayette, upwards of a ton of dynamite and nitro-gelatine have been safely fired in charges of upwards of 50 pounds. I do not think there is another record like this in the world. It is obvious that there are two methods of approaching this problem of safely firing high explosives: 1. By using any kind of high explosive known to commerce, and so modifying the gun and motive power that it is safe. This is the method adopted by the Pneumatic Dynamite Gun Company. 2. By using any kind of a gun with ordinary powder, and so modifying the explosive that, while retaining its strength, it will be safe. This is the method followed in Europe, and has produced the Hellofitte of Russia, the Roburite of Germany, the Parone powder of Italy, and the Melanite of France, while slow but safe-going England has adhered steadily to gun-cotton. All of these substances are said by their inventors to be safe to handle, and can be fired with impunity from any kind of a gun; but the experiments of foreign nations are always designedly wrapped in mystery, and it is very difficult to obtain accurate information, and from what we *do* know I think Captain Zalinski is right in saying that where large quantities of high explosives are used the ultimate dissolution of a gun or guns has always occurred, except in the case of the pneumatic dynamite gun. No experiments have been made by the Government in this country in firing large masses of high explosives. Small quantities of gun-cotton have been successfully fired several times from small guns, but the use of large masses will probably prove a more difficult matter.

Next as regards the relative value of powder and compressed air: the condition of affairs which we are called upon to encounter in firing high explosives is peculiar in many ways. Captain Zalinski's theories with regard to the best way of obtaining an armor-penetrating effect are reasonable, but they remain to be demonstrated in the future. So far as experiments have been

carried on abroad, it is known that the French have found that four inches of armor is ample to keep out large masses of melanite when fired in shells, and they are now constructing a vessel—the Dupuy de Lome—with only that thickness. This bears directly on the present value of firing high explosives with high velocities, and consequent flat trajectories, even if it were safe to do so; and since if the shell misses its object with a flat trajectory there is little chance of any torpedo effect on the enemy when the shell strikes the water, and as this is the most notable feature of the pneumatic dynamite gun anyway, we are driven back to the question of what could be done with low velocities using powder.

Under these circumstances a light gun similar in general features to the Zalinski gun would be the best, because no ordinary gun of that calibre could be carried in such a small boat, to say nothing of three of them. It is safe to say that there is no powder now in existence which could produce a mean pressure of 600 pounds per square inch in that gun at Fort Lafayette, without a corresponding maximum pressure of near 2500 pounds per square inch, which would burst the gun even if it did not cause a premature explosion of the shell *in* the gun. In the present state of the art, however, a low powder could probably be made which would maintain a constant or an increasing pressure from breech to muzzle; but it would be more difficult to make it so uniform that at a given range the shots could be duplicated. Given such a powder, however, and it would do away with the bulky air reservoirs, compressors, etc., but it would introduce other difficulties of no mean importance. The elements of heat and smoke do not come first in importance, but they may as well be considered here. The former is not to be neglected, as the firing point of most of these high explosives is about 350° F., and premature explosions would be liable if the gun were fired rapidly, while with air the gun is continually growing colder. The matter of smoke is important, and up to this time no smokeless powder has been made that will keep. The present pneumatic dynamite gun shows a discharge of steam or watery vapor; but this could be entirely suppressed by drying the air with sulphuric acid in pumice stone, or by some other simple method, and when this gun is used for distant firing from a submarine boat lying just awash it will be almost an impossibility to detect its locality.

But, for our purposes in this boat, there are still other difficulties with powder. Mortar practice on shore has vastly improved of late years, and recent Russian experiments have shown it to be about one half as accurate with a 9-inch mortar as with flat trajectory fire from an 11-inch rifled gun; but it is axiomatic that the mortar bed must be absolutely solid and level, while here we are not only going to have the bed in continual movement from the rolling and pitching of the boat, but the boat itself will be continually under way, and so will the enemy. In mortar practice on shore the effort is made to find a set of ranges, using two or three different sized charges of powder with varying elevations, because the advantages and ranges of mortar fire cannot be obtained in combination with accuracy by using one fixed charge of powder and varying elevations. Now Captain Zalinski claims to overcome this diffi-

culty of changing charges of powder by having his air pressure so absolutely under control that it only requires the movement of a lever to obtain a pressure which with a fixed elevation will produce exactly the range required, no matter how rapidly the range may change. How much the more important to us is this regularity of pressure and rapidity of manipulation in our boat! The record of the gun at Fort Lafayette goes far to substantiate Captain Zalinski's claim when the gun is mounted on a stable platform, and this brings us to the most important part of the discussion—what will it do mounted as it is in our boat? I say *mounted as it is* because, as all three guns are fixed at the same angle in the forward part of the boat, an error of one is common to all (except in rolling), and it is of course obvious that for general fighting purposes an additional gun should be mounted to point aft. It is, I think, also true that this or any other torpedo boat should be either armor-clad or submarine.

The question of its range I do not think of much importance. If we are willing to go within 300 yards to use a locomotive torpedo, we may well be satisfied if with this gun we can commence our torpedo practice at a mile; besides, as we all know, on board ship 1500 yards is generally considered the fighting range, even in target practice, no matter whether the guns are rifled or smoothbore, and there is no naval action on record at over that distance. With the Alabama and Hatteras the distance was 75 yards. The Alabama and Kearsarge commenced at 1200 yards, and the general action was carried on at 900 yards. The battle of Lissa commenced at 200 yards. The Huascar, Shah, and Amethyst fought at 900 yards, while the Huascar, Blanco Encalada, and Almirante Cochrane commenced at 500 yards and finished at 50.

The question of accuracy, so far as lateral train is concerned, depends, in smooth water, entirely upon the handiness of the boat. As she has twin screws and must fight bows on, there will probably be no difficulty about this when under way and steaming toward the enemy; but when lying dead in the water there should be some means of turning the boat rapidly without resorting to the screws, which will always cause her to move ahead or astern while she is turning. A powerful hydraulic pump, with a delivery pipe having a discharge on both bows, and a valve to turn the flow of water in either direction, would be of great assistance in remedying this defect.

The rolling of the boat will affect the accuracy of the two outer guns more than that of the middle one, but there should be no great difficulty in firing the gun by hand or automatically at the middle of the roll if it is not excessive, and if it is excessive no other gun would do any better.

The pitching of the boat is a more serious matter, as we all know that our principal errors at sea are in elevation and not in train. Captain Zalinski has an automatic arrangement to fire when the boat is horizontal; but at the same time it will be well to bear in mind that, although this boat is very sharp, it is not likely that she will ever be called upon to use her guns in any sea that would cause her to pitch excessively. According to M. Bertin, the proportion of the maximum of pitching to the maximum of rolling in most ships is only 1 to 6, and in the experiments with the Devastation, Agincourt, and Sultan it was found that for each *degree* of inclination the bow of the Agin-

court would move vertically four feet and the Sultan three feet. The apparent angle was very great, but *actually* it was very small. In waves 400 feet to 650 feet long and 20 to 26 feet high the average pitch of the Devastation was only 4°, and that of the Agincourt was less. The length of the Devastation is 285 feet and the Agincourt 400 feet. Now the dynamite cruiser is 252 feet long, a very great length in proportion to that of any waves that she is likely to be used in, and her weights are not badly disposed. A change in the vertical height of the whole gun due to such waves would make little difference in the trajectory, while, with regard to the effect of the angular change, this gun has greatly the advantage over a gun with a flat trajectory. As Captain Zalinski says, an error of angle of 15 minutes of a high powered gun makes an enormous difference at the distance of a mile. This was shown with the French gunboat Gabriel Charmes, of 150 feet length and 15 feet beam, on which a 14 cm. gun was mounted. This gun at a range of 1000 metres ordinarily makes a rectangle of 15 metres. Mounted on this boat, however, it was found impossible to hit an island 200 metres long by 15 metres high at this distance when the sea was rough. The general practice of the gun was so bad that it was taken out and the boat converted into a torpedo boat. An error of angle of 15 minutes with the dynamite gun at a mile only makes a difference of 15 yards in the range, while the difference of vertical height would be correspondingly small.

The guns are mounted in the boat at an angle of elevation of 16°, and with 1000 pounds pressure they should have a range of 1960 yards, judging by the performance of the gun at Fort Lafayette. If the elevation were 14° the range would be only 120 yards short, not much greater than the length of the Chicago or Baltimore. If the elevation were 12° (or 4° pitch) the range would be 260 yards short, or less than 2½ ship's-lengths. The movement resulting from a combined roll and pitch will cause more trouble in distant firing with the gun than anything else; but it will probably not affect its accuracy much, if the movement is not excessive, since the controllability of the air pressure gives it remarkably uniform ranges even when its angle of elevation is varied largely, and the torpedo effect of the shell allows for considerable dispersion laterally.

The difficulty to be apprehended, however, is not when the target is a long way off and there is plenty of time to get the range, but when the ranges are rapidly shortening. The mechanical control over the compressed air is so great that theoretically the gun can be adapted instantly to any range within its limits. The great difficulty will be to know what the range *is* at any instant. If you do not succeed in catching the range as you come up, a difficulty will arise at close quarters, in the fact that the theoretical pressures run down so far for short ranges that the valve gear might not work on account of friction; and it is a question whether the theoretical results in the way of expansion, range, etc., could actually be obtained with these very low pressures. A pressure of only 8 pounds at 10° elevation gives about 200 yards range, and you might not be able to fire at all with this pressure, and if you did, might shoot over your enemy or fall short of him. The velocity at this low pressure is 130 f. s., which is more than three times that of a 25-knot locomotive torpedo;

but with the torpedo you have a practically flat trajectory at all ranges. It is plain that the remedy in the case of our boat is to mount one of these guns in a perfectly horizontal position, so as to be able to use it at close quarters with full pressures, and thus "guard against all precautions," as Jackey says. The chances are that you would hit the enemy below the water line or catch him on the ricochet if he were not close enough for the horizontal fire. The necessity of a horizontal gun is still further emphasized by the fact that if we and our enemy are approaching each other at the rate of 20 knots each (I purposely put an extreme case), the total distance passed over in say five seconds will be about 337 feet or a ship's length; but this rate might or might not be the same at all points of the range: you can always regulate your own rate of speed, but you never can regulate the enemy; hence there is a continual uncertainty. To catch such uncertain and rapid changes of range is not impossible, but it will be difficult. The Berdan range finder, which is probably as quick as any, requires from 10 to 15 seconds, and, of course, difficulties are multiplied when one gets on board ship. Still in our boat, which must always fight bows on, we have a length of 26.5 feet in the beam of the ship for an available base line, and either with this or by some other method it is probable that, if we are not too close, we will be able to attain our ranges much more accurately than we could in an ordinary vessel.

The remaining point of immediate importance for naval officers to consider is the nature of the explosive to be used on board ship. To obtain the full torpedo effect it is, of course, desirable to use the most powerful explosive known, and such would undoubtedly be used in time of war regardless of its minor qualities of safety, leakage, convenience of handling, etc., etc.; but in time of peace only such explosive material will ever be taken on board ship as experience has demonstrated is safe to keep in store by reason of its not changing its chemical or physical qualities. The pneumatic dynamite gun has (so far as present experience goes) demonstrated that it is safe to fire these things; but that is a different matter. Those of us who have experienced nitro-glycerine headaches know what it is to handle any of these compounds that are liable to exude it, and it is highly probable that the judgment of any officer or man so afflicted would be worthless in an emergency. Little is known as to how any nitro-glycerine compounds will behave when stowed in the hold of an iron ship and exposed to the extremes of temperature there, especially in regard to heat. I proposed to find this out when in command of the Alarm twelve or thirteen years ago, but it was not deemed advisable by Admiral Porter because it was not necessary at that time to enter that field of research. I now think his judgment was perfectly correct, because in the interval the progress of science has developed gun-cotton into a much more convenient, cleanly and safer material to keep and handle, and it is already in use on board ship. In all these years, although the nitro-glycerine compounds have been developed into the most powerful practical explosive known, and that too by a combination with gun-cotton, still even the best of it will sometimes exude its nitro-glycerine in minute quantities, as Captain Zalinski says. This exudation is of little importance on shore where your magazine can be placed in a locality

remote from the scene of your active operations; but on board ship, where you must always have your magazine within a few feet of you, it would be more comfortable to know that you were in no more danger from your own magazine than that of having some other fellow exploding a high explosive shell in your vicinity. Beside this it should be borne in mind that there is nothing at present more obscure than the correct method of exploding a high explosive so as to get the full detonating effect, and it is quite possible to so arrange the number of fuzes, quantity of fulminate, etc., as to obtain an increased destructive effect beyond what we are in the habit of obtaining. This argument applies equally to nitro-glycerine and gun-cotton, but it tends to show that we might bring gun-cotton up to the point of efficiency that we now expect to obtain with nitro-gelatine in our boat; although, with the accuracy that is to be expected from the guns, I question if the range of torpedo effect would not be ample with gun-cotton as it is now exploded.

Commander ALBERT S. BARKER, U. S. N.—I have carefully read Captain Zalinski's interesting paper on the "Naval Uses of the Pneumatic Torpedo Gun," and although I think him too sanguine in regard to the probable accuracy of fire on land and at sea, still I consider the weapon a valuable one, and well adapted to form an important addition to our coast defenses. But Captain Zalinski errs in stating that all the advocates or "predictors" of the use of high explosives from powder guns "*also demand penetration before explosion.*"

As I was the first one in the United States or on this continent, so far as known, to fire dynamite shells—having in 1874 begun with small tubes and worked up to the 24-pounder howitzer; having officially advocated the use of high explosive shell-firing from powder guns, and believing now as firmly as ever that gunpowder will soon be used as the propelling agent—I claim the right to be counted as a "predictor" who has *not* insisted upon "penetration before explosion." The article describing my experiments is printed in Vol. XII, No. 4, Naval Institute Papers. It will be seen that I advocated the use of our smoothbore guns to do the very thing that Captain Zalinski states that the pneumatic gun will do, viz. *project torpedoes;* and I stated then that should it be demonstrated that gunpowder could be used, it would to a great extent do away with the Whitehead, Lay, and torpedoes of like kind. The same claim is made now for the pneumatic gun. Captain Zalinski states that the pneumatic guns are now being made shorter, hence it is reasonable to suppose that the tubes are thicker to withstand an increased pressure. The tendency therefore is to bring the pneumatic gun to the dimensions of the powder gun.

I still think, as I stated officially in 1874, 1878, and 1882, that the subject of firing high explosives from great guns using gunpowder as the propelling agent is one of the most important matters for our Government to consider. Experiments should first be made to show the capabilities of our smoothbore guns for projecting torpedoes, and then it would do to work up to the rifle guns. I was present when the Silliman was sunk in New York harbor and was delighted at the success of the experiment. It gave some idea of what can be expected of torpedo shells. Now, the projectiles which destroyed that vessel *could have entered the bore of a 9-inch gun.*

Suppose it could be shown by actual experiment that a powder cartridge could send a similar projectile the same distance, we should see at once that 9-inch smoothbore guns would make a very effective secondary battery for our large men-of-war; and on all ships a few could be carried, which would not only be effective as now used, against an ordinary man-of-war, but could in addition project torpedo shells to a greater distance than automobile torpedoes are now expected to reach with effect. Moreover, the ordinary machine-gun projectile would not injure them, hence if kept loaded and ready for use there would be comparatively little danger of accident. I need not attempt to state what *might* be done, but all must see that if gunpowder *can* be used to fire high explosive shells, or to project torpedoes, warfare is made much more simple.

I do not apprehend the least difficulty in the use of a fulminate of mercury fuze. In my opinion it could easily be guarded from a shock which would detonate it prematurely. A few experiments would determine this and many other things which volumes of written opinions would not settle. When the dynamite cruiser is finished I trust it will be thoroughly tested, and if it prove a success, that others will be built. Let pneumatic guns be mounted in every harbor, and let every reasonable encouragement be given for perfecting them; but while doing this, let the Government also encourage the more important matter of developing high explosive firing from powder guns. There is room enough for both in our systems of attack and defense.

Professor CHARLES E. MUNROE.—A short time since a contractor who desired to destroy a boulder which obstructed his work tried repeatedly to blast it by detonating considerable masses of untamped gun-cotton upon its surface, but without producing any material effect. When called upon to assist him, I inserted a quantity of the explosive (less than one fourth as much as was previously employed) in a hole in the boulder and tamped it, and on firing, the boulder was reduced to fragments. This is a very commonplace experience with the high explosives, and I only mention it here to say, that it was with facts such as this in mind that in 1885 I formulated the conditions which determine the efficiency of projectiles filled with high explosives.

In determining these conditions I assume that one of four effects may be produced, depending on the resistance of the armor to penetration, and on the material, thickness of wall, profile, weight and velocity of the projectile.

(1). The projectile may either penetrate the armor partially and explode in place, or pierce it completely and burst inside the ship. This is the condition of greatest efficiency.

(2). It may explode immediately upon impact and before breaking up. Then the explosive will exert the energy which it develops through explosion in a resisting receptacle.

(3). It may rebound before exploding. Then the effect will be reduced by the interposed cushion of air.

(4). It may break up before the explosion takes place. Then the energy of the explosive will be simply that which it develops when exploded unconfined.

In considering the effect of the pneumatic gun projectile, it becomes evident, from the material of which it is made, the lightness of its walls, and the low velocity with which it is propelled, that penetration is impossible. In fact, Captain Zalinski states that the shell will be crushed on impact; then the conditions which prevail tend to produce a low degree of efficiency. But to meet this criticism Captain Zalinski has devised a most ingenious hypothesis. He holds that the inertia of the explosive will act as a tamping or as a confining envelope. This hypothesis is one which easily admits of being experimentally tested, and it is much to be regretted if Captain Zalinski has failed to do this.

As the pneumatic gun does not realize the highest conditions of efficiency, it is yet too early to cease our attempts to secure these conditions with the simpler and more manageable gunpowder gun. Even if the highest degree of efficiency is not secured, but is only approximated to, such a result will be in the interest of economy and efficiency, for we can more readily and cheaply provide new projectiles for our existing guns than we can provide both new forms of projectiles and new forms of guns. Besides, we must continue such investigations, or we are likely to be left behind by the European nations who are now actively engaged in this development of the service weapon.

Lieutenant Karl Rohrer.—I have read with great interest the paper of Captain Zalinski, 5th Artillery, and congratulate him upon the success he has achieved with the pneumatic torpedo gun. I regret, however, that he did not devote his great zeal, perseverance and ability to the development of his legitimate arm, the powder gun, in the same direction. Had he done so, I feel sure that he would have been equally if not more successful. As between the pneumatic torpedo gun and the powder gun, any unprejudiced man must admit that the *raison d'être* of the former is the inability of the latter to do the same work; and certainly it is not sound policy nor good economy to introduce into our armaments a novel, cumbersome and complicated system of ordnance until a necessity therefor has been demonstrated. When it is experimentally decided that the powder gun cannot be used safely, accurately and rapidly for throwing torpedo shells of all desirable sizes and weights charged with a high explosive body, then let us unite our efforts to introduce into the service the pneumatic torpedo gun.

Lieutenant J. M. Bowyer.—I have carefully read Captain Zalinski's article on the naval uses of the pneumatic gun, and am convinced that this gun has many very good points, the chief of which are its lightness, and the enormous weight of a high explosive that it can hurl at an adversary or into a mine field.

There seems to be no reason to doubt that for countermining (a purely naval duty) this gun will be admirable, since the target will be fixed and a smooth sea may be chosen. In advancing to the attack of the mine field, however, this weapon should be protected from the fire of the enemy by a battle ship on either side of the vessel carrying it.

The thin barrel of this gun is too vulnerable to machine and rapid-fire guns. This, as Captain Zalinski suggests, is also a defect of the over-water discharge

tubes used in foreign services with the Whitehead torpedo; and this is so serious a defect that it demands and is receiving much consideration. If the barrel of this gun should be pierced or battered by the enemy's gun fire, there would be great danger in discharging it thereafter, for either the gun would be torn to pieces by the projectile, or *vice versa*, and the vessel might be hoist by her own petard.

The experiments that have been conducted by Commander Barker, Mr. Grayden, and Mr. Smolianinoff, in firing high explosives from smoothbore guns using powder, have encouraged many naval officers to believe that our old smoothbores, considering their greater range, flatter trajectory, and less vulnerability, will prove more effective than the pneumatic gun. I for one am inclined to doubt the efficacy of high angle firing from an unstable platform at a movable target and at an unknown range.

Lieutenant S. A. STAUNTON.—I do not think Captain Zalinski has strengthened his arguments in favor of the dynamite gun as a purely naval weapon by making a comparison between it and the automobile torpedo. The latter has been before the public for nearly twenty years; has had thousands of trials under varying conditions; has had many failures and many successes; has been of late years subjected to tests under circumstances assimilated as nearly as possible to those of actual warfare; and has steadily won its way to the front as a recognized naval weapon; and the manufactories at Fiume and Berlin are kept running up to their full capacities, and are each turning out 600 torpedoes per year, to fill the orders of the maritime powers.

The dynamite gun has had no such experiments as those which have determined in the eyes of experts the value of the automobile torpedo; and until some record of firing from a rolling and pitching vessel at a target at varying distances can be presented, no comparison of real value can be had. The Silliman trials aroused great interest, and very justly inspired great expectations of the future of the new weapon, but the Silliman trials were as much in favor of the pneumatic gun as the test runs for accuracy at Fiume and elsewhere are in favor of the torpedo. Under similar circumstances, gun and target stationary, and distance suited to the capacities of the weapon, the showing of the automobile torpedo in its present perfected condition would probably have been better. Under conditions similar to those of actual combat the automobile torpedo has often failed, but has sometimes scored successes. Last summer, during the Italian manœuvres, two ships pasing each other at full speed at a distance of 300 metres fired torpedoes from their lateral tubes with such effect that the umpires decided them both destroyed; and ships at anchor, protected by broadside nettings, were struck by torpedoes fired between the defense nets from boats that had taken position ahead or astern. It is hardly just to call this weapon "inefficient," and the promoters of the Howell torpedo, with its inherent directive force, expect to show still better results. The unfavorable criticism of the Whitehead is based upon its action under service conditions; the sanguine expectations as to the pneumatic dynamite gun are predicated upon its behavior under special conditions peculiarly favor-

able to the gun. A good many questions remain to be answered. The gun has hitherto, I believe, been fired only from a fixed platform and at a stationary target. What will it do when fired from a moving platform at a moving target? Accurate firing depends, 1st, upon reliability of the projectile—meaning that with the same initial velocity, elevation, and air resistance, the same result will follow; and 2d, upon knowledge of the distance.

Granting that the projectile is reliable—and the New York experiments appear to have satisfactorily settled this point—we are always met in naval warfare with the difficulty that the distance is only approximately known, and that, even if correctly estimated or measured, the chances of hitting the target are limited by the motion of the gun. Especially at night are estimates or measurements of the distance uncertain and difficulties of pointing great. This uncertainty will probably diminish the fighting range. It may not be more than 500 yards, may be as little as 100 yards, and will doubtless rapidly shift between even greater limits. The flat trajectories of powder guns and automobile torpedoes make them especially valuable at close quarters; the torpedo may miss a ship, but it can't go over her; and with the high powered rifle, variations in range within 500 yards may almost be ignored.

Not so the pneumatic gun. Its fire is essentially a mortar fire. The judgment of distance must be accurate to within the danger radius of the projectile, and the gun must be correctly laid at the instant of firing. Its fire must always be a mortar fire to obtain the torpedo effect, upon which the author so justly lays stress as the chief value of the gun; for at low angles of fire the projectile would ricochet and the torpedo effect would be lost. The elevation cannot safely be less than twelve degrees. With a horizon obscured by darkness or smoke, how is it to be known when the gun is at its proper elevation? What is the "automatic device" for retaining the firing lever till the ship is on an even keel?

The range is diminished by decreasing the air pressure. To what point must this be reduced for ranges under 500 yards? And will the action of the projectile be true and reliable with this feeble impulse? What effect will strong winds have upon its accuracy? Will it be practicable to change the range as rapidly as two ships change their distance from each other, and has this nicety of adjustment been reached, even with a gun mounted on shore?

What is the track of the projectile under the water? As it tends to ricochet, does it go deep enough below the surface to be dangerous at the distance at which a fixed mine would be dangerous? Or if it dives, how soon does this action carry it beyond the limit of danger? Speculation on the track of a rotating projectile after striking the water is the merest speculation. Theoretically it should deviate to the right or left according to the direction of rotation, and it may be found that the rotation necessary to an accurate trajectory in air has destroyed the certainty of the under-water trajectory. All these questions and others must be answered before there is enough testimony to enable a professional jury to give a verdict on the pneumatic gun as a naval weapon. To ask them does not criticise the gun, but points out the work which yet remains to be done. It is just to Captain Zalinski to say that he evidently considers

the true sphere of the dynamite gun to be fighting at a range entirely beyond that of the automobile torpedo; but in a lecture on "Naval Uses," he perhaps felt that it was incumbent upon him to occupy the entire field. Admitting its practical efficiency at long range, the capacities of the two weapons might be defined as follows: The torpedo efficient within 400 yards; both torpedo and dynamite gun of some use between 400 and 1000 yards, the gun increasing in efficiency as the torpedo diminishes; and above 1000 yards the gun possessing the field. From this point of view there would be no rivalry, and therefore no comparison would be necessary.

It would be very unfair to the pneumatic dynamite gun and to Captain Zalinski's paper to carry criticism beyond the point calculated to stimulate discussion and encourage future experiments. What has been fairly proven by the New York trials is the remarkable certainty with which effects can be reproduced. The grouping of the shots in the Silliman experiment was extraordinary, and proved the reliability of compressed air as a propelling agent, and the perfection of the mechanism by which it is applied. The gun, whether it becomes a naval weapon or not, has, in all probability, a decided future, and Captain Zalinski puts it very well when he says, in closing his admirable paper, that it at least supplies some means of striking a blow in return, should an attack be made upon our otherwise defenseless coasts.

The purchase of the dynamite gunboat is exceedingly good policy on the part of the Government. Its possession will give the opportunity for exhaustive test and trial under all the conditions that may arise in naval warfare, and a moderate amount of money could not better be expended than in investigating the capacity and limitations of this remarkable weapon.

Lieutenant HAMILTON HUTCHINS.—In reading the very interesting paper by Captain Zalinski on the pneumatic torpedo gun, the argument in its favor seems to be a strong one within certain limits. It would seem that this is especially the case when the pneumatic gun is used to take the place of automobile torpedoes. I consider that the pneumatic torpedo gun has several advantages, reflects great credit on the inventor, and is justly entitled to be regarded as a valuable adjunct in warfare. Let us first look at the offensive. Here it will no doubt be apparent to all that its principal use would be in countermining. The experiments thus far made with the gun have been comparatively few. It remains to be seen what the gun will do on an unsteady platform. The gun is so long that it is necessary to make allowance in firing for the time occupied by the projectile in passing along the bore. This time is large compared with the powder gun, and of course the longer this time the less liable is one to judge of it accurately. Granting that the gun can do the work better that belongs to most of the automobile torpedoes, it will hardly replace the Howell. The latter, I believe, is accurate in its course, and can be fitted with a contrivance which will allow it to pass under a net and bring up under a ship's bottom. As an offensive weapon, then, it would be used in countermining. Its sphere of usefulness would not extend to bombardment, unless its range is further developed; as a defensive weapon it would be powerful for harbor protection.

If we can judge from experiment, it would seem that high explosives can be and have been fired from powder guns with safety. This was done at the Torpedo Station many years ago from small calibre guns. There is nothing up to the present time to indicate that the efficiency of powder guns using high explosives is in any way impaired, as compared with the pneumatic gun; and until then, no far-seeing man would advocate the former being replaced by the latter. Allowing that the work done is the same in the two different systems, that system would be the best which has the advantage as regards space, handiness, and protection from fire. These qualities are clearly possessed by the powder gun.

Commander Goodrich.—During the existence of the board on the pneumatic dynamite gun, it would have been manifestly improper on my part, as a member, to join actively in this discussion. The dissolution of the board, which took place but a few days ago, relieves me from the obligation of silence, while, at the same time, it has left too brief a time in which to prepare an analysis which shall be at all exhaustive. For this reason I confine my remarks to pointing out certain facts in the experiments before the board, and certain qualities which this gun possesses, that, I think, should not be lightly passed over.

In these days of rapid change in the material of war it is idle to suppose that a finality has been reached. No one doubts that eventually large masses of high explosive will be projected with safety from powder guns. The pneumatic gun cannot be expected to carry its shell through armor, except of the very lightest description. Indeed, the promoters of the enterprise disclaim any thought of offering the weapon as a substitute for powder guns. Yet it must not be forgotten that, provided the quantity of high explosive be large enough, its detonation outside of a thick wall of armor may, and doubtless will, be attended, through concussion, by very serious damage to persons within. Every ship, however completely protected, exposes a large surface in the shape of decks, superstructures, and unarmored ends whose resistance is very slight. A successful over-water shot from the pneumatic gun would doubtless produce injury extending over a wide area; and here again the effects of concussion upon the ship's company will be great—how great it is impossible with our present data to exactly foresee.

The torpedo action of the dynamite shell has been demonstrated as efficient, subject to the limiting conditions of the experiment. The Silliman was destroyed by torpedo action pure and simple. There is no other instance on record of a torpedo with a proved radius of destructive effect of a mile. Again, the dynamite gun offers possible value in countermining, in spite of the failure of the series of experiments devised with special reference to clearing this point. I am willing to leave this field open to future experimentation, but I have no hesitation in recording my belief that a successful result will be reached eventually.

Up to the present moment, whatever has been done with this gun was from a fixed platform and over a known range. There can hardly be any objection to this mode of procedure, certainly as far as the early stages of development

are concerned. We do the same thing with powder guns, and upon the data yielded by firing under fixed conditions we predicate the usefulness of the gun at sea. Owing to the great length of the gun tube and the slow motion of the projectile through it, the air gun will be more seriously influenced than the powder gun by the motion of the platform. This is one of the inherent disadvantages of the former, yet it must be weighed fairly and impartially against the merits of the piece and a just balance of advantage struck. It appears as if this quality would in practice restrict the air gun, in its present shape, to employment for coast and harbor defense, where a stable platform is the rule and not the exception. Captain Zalinski's proposition to use a sub-calibre projectile and reach a higher initial velocity with a shorter tube may prove successful and thus widen the scope of the arm. In connection with this proposition it is proper to indicate the grave chances of disaster. So rapid an acceleration of velocity in so short a space must thrown great strain upon the explosive charge and largely increase the risk of premature explosion in the bore. I should be loath to see this practice adopted, except after most complete experimental investigation. My opinion is that this investigation will end in failure if pushed too far. In its present state of development I can foresee no application of the pneumatic dynamite gun to cruising vessels, except possibly as a torpedo gun of short length, for tossing torpedo shells over short ranges—greater, however, than that of the Whitehead. Used in this way, the adversary's net would be of little avail, while the shell would have a two-fold action: the first, in striking the over-water body, and the second as a torpedo. I am not, however, prepared to recommend the gun for this use, or for general adoption in the service, until complete experiments with the cruiser now building shall have demonstrated its value beyond cavil.

The use of compressed air in a gun must always present one considerable advantage over the use of powder, in that the gunner is enabled to regulate to a nicety the amount of energy put into his projectile, and therefore vary its fall within singularly narrow limits. But this advantage is secured at a large price in the way of extra weight carried and special appliances for compressing and storing the air. Indeed, this whole question enjoys no special immunity from the universal obligation to pay for what you get. If it be granted that the results which may be achieved with this gun are desirable, it must always rest with the authorities to decide whether or no these advantages involve too great a sacrifice of other desiderata.

For coast and harbor defense, the ability to vary the range by altering the pressure must always remain a strong argument for the partisans of this gun. I am disposed to think, however, that it will be a long time before we shall see this gun on board of cruising vessels, unless some better means be devised for securing the air compression than the complicated, cumbersome, and heavy pumps incident to the system in its present state.

Even if the pneumatic gun be but a step leading to something better, it must be borne in mind that charges of high and sensitive explosive have never before been safely thrown in such large masses and with such accuracy.

I think it a duty to speak of the way in which this gun has been presented. Too frequently new inventions are offered in the shape of crude ideas on

paper, to be developed at the Government's expense and to the inventor's profit. To this rule the pneumatic dynamite gun has been a notable exception, for it was laid before the department as a weapon ready for use, to be accepted or rejected on its merits. As a solution at hand of a serious problem, not probably final, but likely to serve a useful end for some time to come, I can but think it was wise for the Department to test the gun on a practical scale. Time alone can show how permanent will be this addition to existing modes of attack. If it fails under conditions of actual service we shall be no worse than before. If, on the other hand, it succeeds, how much regret will we be spared! For once will be broken the record of indifference to American inventions as exemplified in the cases of Treadwell's built-up gun, Chambers' slotted screw breech mechanism, Hotchkiss' non-recoil guns, etc., etc., all of which had to cross the ocean to find due appreciation.

I must deprecate the author's suggestion, implied if not expressed, that it is idle to seek safe projection of high explosives from powder guns coupled with penetration of armor plates. Whether these can be secured or not, experiment alone can determine, but no one should question the utility of the research. The air gun can never, broadly speaking, get through armor—the powder gun can.

The highest prudence demands our finding, if possible, a means of bursting our shells with maximum destructive effect after penetration, that no part of our enemy may escape. I am certain that this result will be reached in the near future. While such shells cannot be expected to contain so large a proportion of explosive as the thin-walled case of the pneumatic projectile, yet the damage inflicted by the former behind the armor will doubtless be more serious than that produced by the latter outside the plating.

Nor can I share the author's belief that thin cases of high explosives will not be fired from powder guns. Their velocity may be lower than the present standard 2000 f. s., but I am confident that safety and a fair degree of range and accuracy will be secured.

High powered guns must be carried at sea. Is it not obligatory on us to seek a means by which they may be made at will to do the same work as the pneumatic gun? Captain Zalinski should remember that the same spirit which recognized the possibilities of his weapon can never be satisfied with standing still. If something better be found it will surely be adopted; if it be a good thing in a different yet allied field, then we will have two strings to one bow—two modes of attack.

In conclusion, let me suggest that the weapon developed by Captain Zalinski is as yet experimental, and has still to undergo the crucial test of practice afloat. Whatever be the outcome, let this be said of the naval service, that it treated the newcomer with courtesy and without prejudice, and that the latter stood or fell after a fair and impartial trial.

NEWPORT, R. I., *January* 31, 1888.

Captain E. L. ZALINSKI.—*Mr. Chairman and Gentlemen*:—As suggested by Lieut.-Commander Barber, it has been a rather noteworthy feature in all discussions and criticisms made by army and navy officers, that they would concede

a possible field of usefulness for the pneumatic gun for the *other* branch of the service. This is exemplified by the remarks of General Abbot and Admiral Simpson.

General Abbot points out the danger of the fixed mines of the defense being exploded by the aerial torpedo shell. He thus concedes the probability of the enemy being able to destroy his fixed mines should they be equipped with pneumatic guns for countermining. This they will certainly attempt before endeavoring to run the gauntlet of the fixed mines and shore defenses. They can countermine as readily at night and with as great certainty of results as in the daytime. Should the mines be set for contact rather than judgment firing, as would be the case for night defense, the countermining operations of the enemy would simply be facilitated; the countermining shell would in this case have a larger effective radius. To attempt to supply the place of exploded mines by slow-moving, uncertain, and expensive dirigible torpedoes would be difficult and unreliable in the daytime; much more would this be the case at night.

The pneumatic guns used by the defense would cover very large fields which it would be enormously expensive to cover entirely by fixed mines. Besides this, if the fixed mines are of proper design, an exact knowledge of the location of those unexploded by the enemy's countermines would be at hand. The pneumatic guns need not be directed on those portions of the torpedo field still intact and operative, and they could be concentrated on other portions where the enemy's countermining operations or our own act had removed the fixed mine defenses.

It should not be overlooked that an entire system or group of mines may be rendered innocuous by injury of the cables or the ducts leading to the operating rooms. It is probable that an enemy will endeavor to ascertain the position of the operating chambers and the plans of the entrances to the same. They may not be unsuccessful, and they might use their countermining shells so as to destroy the operating cables of the system. This portion of the defense, the fixed mines, may thus be rendered innocuous.

It is hardly possible to imagine a complete and efficient alternative defense being effected by the slow-moving and difficultly directed torpedoes called "dirigible."

It is true that the pneumatic guns are somewhat easily injured if hit and exposed fully to the enemy's fire; but they may be very thoroughly protected in sunken emplacements not exposed to the enemy's direct fire. It is impossible to conduct operations of war without receiving some injury occasionally. Provision is made for this by having a larger number of guns.

The fire of the pneumatic guns is characterized as "mortar" fire both by General Abbot and by Admiral Simpson. As the guns of the dynamite gun cruiser are fixed at an angle of 16°—and it is not proposed usually to fire much above that angle—it must be due to misinformation that these distinguished officers should have called fire at this angle "mortar fire." They certainly would not characterize powder guns' fire at 16° elevation as being "mortar fire," unless a new classification is made as to artillery fire.

General Abbot concedes the utility of the gun *for the Navy* when "mortar" fire is needed for use from shipboard. *High angle* fire with low velocities *is* needed from shipboard. Experiences at Alexandria and elsewhere have shown that long range firing from shipboard is practically useless, and that ships will have to come to close quarters of from one to two miles to produce any effect on modern fortifications. If many of these are sunken emplacements or on high ground, the very high velocities of the high powder guns will cause the shell to pass over the works rather than to drop within them. The high angle fire and curved trajectory of the pneumatic guns will in these cases be especially *advantageous* rather than detrimental.

General Abbot is cognizant of the difficulties involved in placing fixed mines where the tidal currents are swift and where the tides rise and fall considerably. In many such places fixed mines can hardly be placed so as to be efficient at all times. Dirigible torpedoes in such channels become even more difficult to direct. Foreign torpedo authorities have recognized this, and have conceded that the pneumatic gun will in these cases fill a place in the defense not possible by any other appliance yet presented for practical use.

Lieutenant-Commander Barber, in his remarks, has made an analysis of the conditions involved in use on shipboard which is valuable and instructive. I have endeavored not to absolutely insist on explosive gelatine as against gun-cotton. If, however, in time of war it is found that the gelatine is most desirable on account of its superior "*volumetric*" energy, provisions can be made against possible deterioration by cooling the magazine by means of compressed air or other method. In no case would it be necessary to handle the gelatine or other explosive, as it would be made up in suitable cartridges and the shell loaded before being placed on shipboard. The danger mentioned by Commander Barber, of the crew becoming affected with severe headaches due to handling these explosives, will be avoided.

Commander Barker deserves great credit for having been the pioneer in the attempts to throw high explosives from powder guns, and in this direction he has really done more than the recent much vaunted exploits of Graydon. Unlike the latter, I believe Commander Barker's experiments are about the only ones that have not ended in the dissolution of the gun. Notwithstanding his success in this way, it is agreeable to see that, without giving up the idea of throwing high explosives as bursting charges of powder gun shell, he recognizes the independent field of the pneumatic gun torpedo. It is true that the shell used in the Silliman trial could have been inserted in the bore of a 9-inch powder gun, but it is not yet established that it could have been fired out of it so readily.

Commander Goodrich recognizes the danger incidental to the greater initial acceleration of the sub-calibre shell when used in the pneumatic gun, yet he pronounces emphatically that the high explosives will be thrown from powder guns. As I have previously pointed out, the real question at issue is not the throwing of charges, which form but a small percentage of the total mass of the projectile. The possibility of doing this is conceded. No success can be claimed for the gunpowder method until the percentage of the high explosive thrown has been at least fifty per cent of the weight of the projectile, and until

this has been done not less than one hundred successive times without premature explosions taking place either in the gun bore or just outside.

Had Professor Munroe carefully read some of the papers previously published on the gun experiments, and portions of which he had republished in the U. S. Naval Institute Proceedings, he would have seen that the value of a tamped charge as compared to an untamped charge had been fully recognized and that definite experiments had been tried proving this. These experiments were made by explosions of charges suspended against iron plates and by firing the charges from the pneumatic gun against the iron plates. The Professor misapprehends as to the arrangement of the shell. It is not intended that the part containing the charge is to be crushed on impact before explosion can take place. The electrical arrangements are such as to insure explosion before the body of the shell can be crushed. In this way the tamping effect of the encasing shell is obtained, as well as from the initial detonation taking place at the rear of the charge.

Lieutenant Staunton is mistaken in the assumption that the Whitehead torpedo is considered a success in Europe, if one may judge from the reports of trials as given by the professional publications. Future trials under service condition will alone fix the relative value of the powder gun, the automobile torpedo, and the aerial torpedo of the pneumatic torpedo gun. When the automobile torpedo misses the ship it is lost; if the aerial torpedo misses the ship it still has certain chances of efficiency. The change of range will be obtained by a device which avoids the necessity of constantly changing the pressure. This can be done continuously with the change of range, so that the gun may be fired at any instant chosen. It was not intended to advocate the entire displacement of the automobile torpedo in the naval armament by the pneumatic gun. There is doubtless a field of usefulness for these when coming to close quarter work and for surprise attacks.

Admiral Simpson objects to the use of the gun on shipboard on account of the necessary paraphernalia of reservoirs and compressors. These, however, have been accepted in a more limited degree for use in connection with Whitehead torpedoes in foreign navies. They will also be required for use with pneumatic systems of gun carriages, cooling processes, etc. The compressors do not take up much room, and the reservoirs can be distributed so as to interfere but very little with the space required for other purposes. It is a notable fact that the modern ship of war is a very much more complex affair than war ships of the past, a large variety of engines are required and the ship is a mass of machinery. Progress in naval warfare has continually replaced steam for manual power. The naval officer of the past, returning to earth, would be horrified to see the extent to which the mechanical engineer and machinist replaces and supplements the sailorman of his day.

The Admiral does not, in my opinion, give full consideration to the chances of successful fire due to the relatively large horizontal target presented by the deck and the large danger zone surrounding the vessel. It would appear to me that these chances are much greater than those attainable by the best known torpedo. The torpedo used in the Destroyer has a range of only 100 yards, and has failed in trials made at a target placed at a less distance. So far as I can

learn, a shell fully charged even with gun-cotton has never been fired out of the Destroyer's gun.

It is idle at present to argue farther upon this matter beyond the extent already entered into, in view of the fact that practical trials will be made very soon with the guns mounted on the pneumatic dynamite gun cruiser. This trial should, if possible, be a comparative one with vessels using high power guns and with torpedo boats carrying the best known automobile and dirigible torpedoes.

Superhuman certainty of action is not claimed, but a high relative factor of efficiency, it is hoped, will be established by such trials. As stated by the Admiral, it is true that a single torpedo boat carrying the pneumatic torpedo gun may be disabled by an enemy's fire before getting in a successful blow. But this is much more the case with the ordinary torpedo boat and torpedo boat cruisers which are advocated by the Admiral. These last must approach within at least four hundred yards, whilst the torpedo boat with the pneumatic torpedo gun can commence operations at more than three times that distance. In this connection I quote from the Admiral's very able paper on "Modern Ships of War": "The torpedo boat is undoubtedly one of the features which should be introduced into our new Navy, not only for their possible use on the high seas, but for the purpose of supplementing the harbor-defense vessels; while the type of vessel known as the torpedo boat catcher would be a powerful auxiliary to the armored cruisers on the first line, or the more powerful vessels forming the second line of the coast defense." It is evident that the Admiral, in common with other authorities, considers the risk involved in approaching a war vessel by torpedo boats unavoidable and to be accepted. I cannot, therefore, having such excellent authority, accede to the assertion that the torpedo boat carrying the pneumatic torpedo gun will certainly be destroyed by the enemy's fire before it has a chance of injuring the vessel attacked.

Attempts to fire large charges of high explosives out of powder guns have been persistently made by European nations as well as by ourselves, and have invariably ended in failure. Italy has been willing to purchase a gun for trial, and indeed has been constantly urging haste as to its construction, shipment, and trial. This does not indicate that the question has been solved abroad, as appears to be the opinion of General Abbot and others. Certainly all attempts in this country have utterly failed when the charges to be thrown formed more than seven per cent of the total weight of the shell.

It does not seem probable that the attempt to make the "dog wag the tail," in the manner suggested by Admiral Simpson, is likely to succeed, in view of past experience. To desensitize the explosive to the extent of enabling it to be fired in powder gun shells, when it forms a large percentage of the weight of the latter, does not appear to be compatible with a probability of its producing marked effects when it is to be exploded against or within an armored target.* The very condition of stability which prevents the resolution of the explosive into its constituent gases when the explosive is subjected to a very severe shock, as when forced from the powder gun, would militate against the probability of the very ready and rapid resolution and evolution of its gases

which produce the great effects of the high explosives. When shell charged with considerable quantities of high explosives have been successfully fired through armor exceeding ten (10) inches and made to explode *after complete* perforation and penetration, it will be time enough to consider the feasibility of doing the same with bursting charges of the high explosives.

The French experiments with mellinite have not been universally successful. They have certainly met with some disastrous failures, as have other European powers in their efforts to throw high explosives out of ordinary powder guns. The simple fact that the French are manufacturing thin steel shell of 21 cm. calibre does not necessarily imply continued confidence in their ability to use mellinite or other high explosive out of the powder guns. It may be that they contemplate the use of these same shell as torpedo shell loaded with large charges of gunpowder, after the manner of the Germans. They are not likely to publicly announce their intention to renounce mellinite after their unqualified statements as to the successes obtained. The resulting failures that have leaked out were not announced as frankly as were the preliminary successes.

Although a slight degree of success has been obtained by dirigible balloons, it is not immediately probable that this means of navigation is to replace all other means.

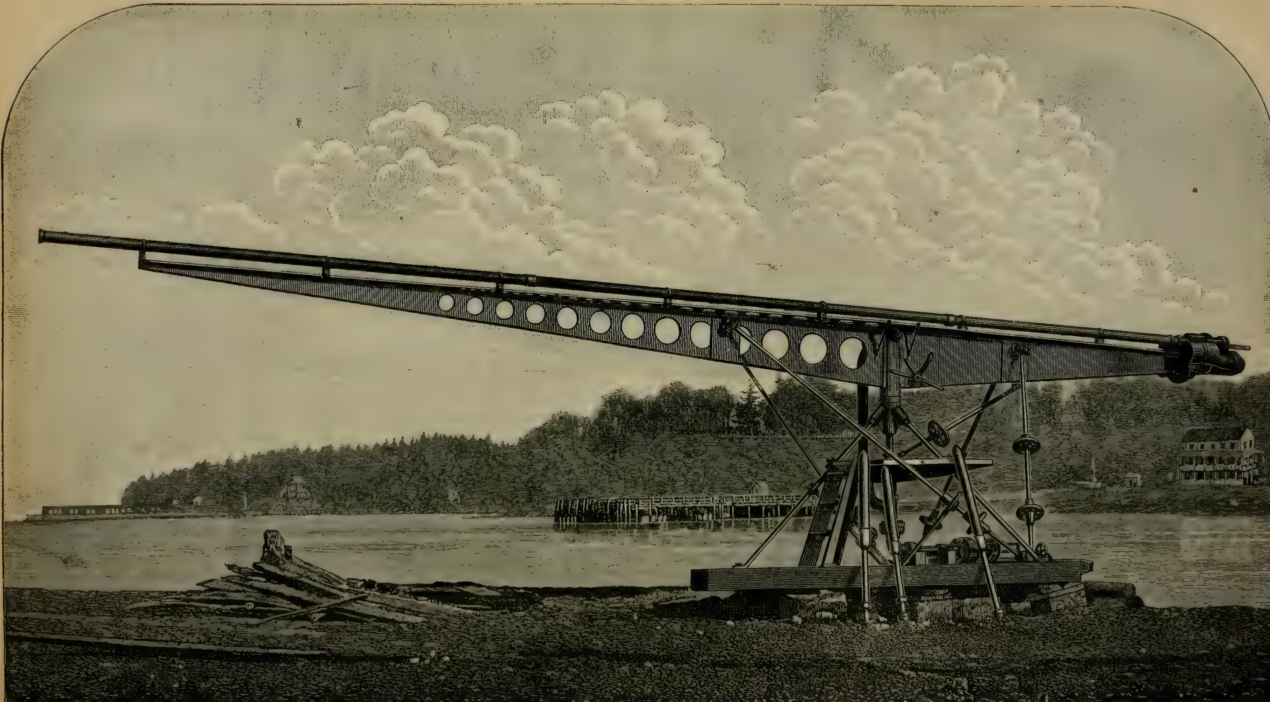
The mere statement that it is probable that very large charges are to be thrown out of ordinary powder guns should not prevent present action as to the adoption of a method which has proved successful beyond any other heretofore tried.

Certainly it would not appear to be justifiable, for the United States especially, to limit its armament to ordinary torpedoes, in view of the possibilities opened by the pneumatic gun. It will hardly be accepted by Admiral Simpson that we should desist from preparing to build built-up steel guns because some one prophesies that cast steel guns of large calibre can be built in the near future. This policy would result in nothing being ever done, because a time will never come when some enthusiast may not predict that something better than existing means and methods will be adopted in the near future. It is this very spirit which the Admiral deprecates as to guns and ships.

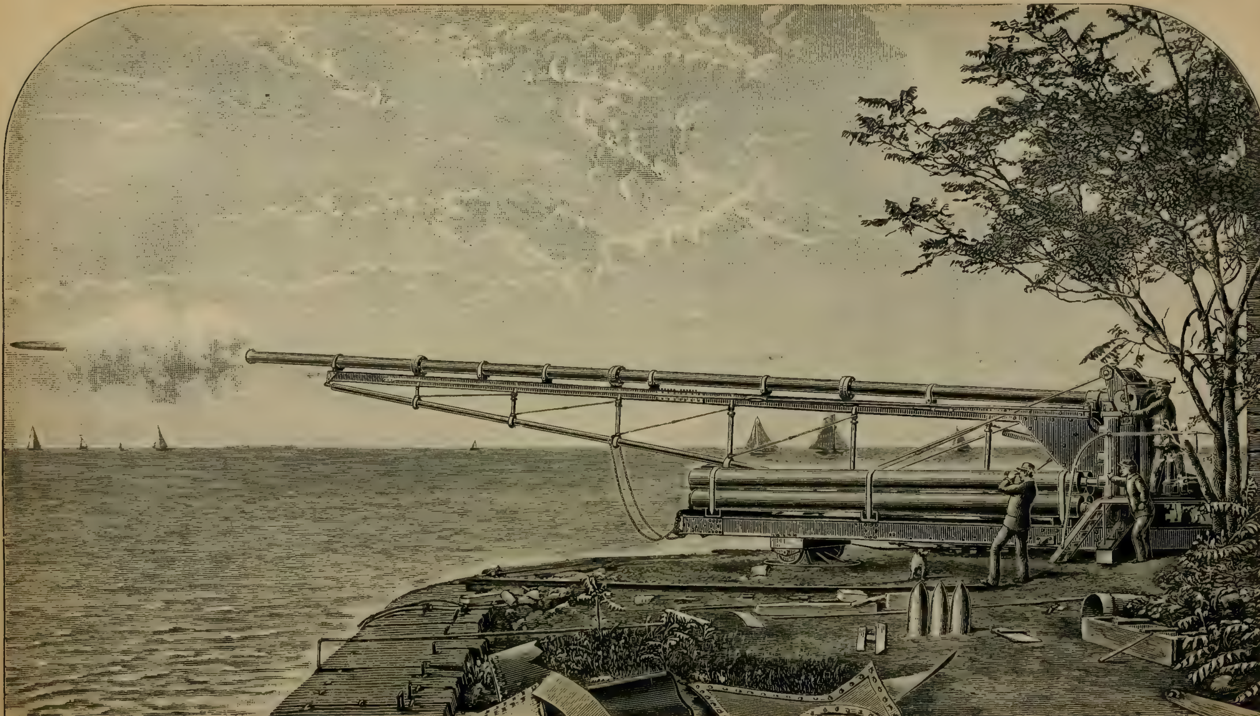
We cannot always afford to await future developments. We must provide the best that has been found to be successful. When something better is developed, that in turn must replace the former. Armaments must be changed, as are the tactics of an army, to conform to ever changing developments of the art of war. It involves expense, but it is the insurance a nation pays to provide for its defense.

Come what may, we have at hand a weapon which enables us to meet the most powerful ironclad afloat with a *chance* of obtaining success. Can this be said of any other weapon we now have or are likely to have within the next few years? Forlorn hope as it may seem, our gallant naval officers will welcome the opportunities which the pneumatic gun places in their hands. Arguments as to the probable use of gunpowder for this purpose will be relegated to the times when it becomes an accomplished fact.

TWO-INCH PNEUMATIC TORPEDO GUN.



FOUR-INCH PNEUMATIC TORPEDO GUN.



EIGHT-INCH PNEUMATIC TORPEDO GUN.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON THE NAVAL BRIGADE.

By Ensign William Ledyard Rodgers.

The study of military affairs should always be interesting to naval officers, for it has always been the pride of every navy that no mode of fighting could be altogether foreign either to its inclinations or abilities; but aside from this, military tactics may frequently throw great light on purely naval matters. For instance: many of the fire regulations and much of the fire tactics of field artillery are directly applicable in naval gunnery; and the experience of the German infantry in 1870–71 may even be applied to the subject of armor protection, since it was then observed that as the Germans advanced, the opening of their fire was attended by a large diminution of their own losses. Hence it follows that the gunnery skill of a ship's crew forms a part of her protection as well as of her offensive powers, and it does not seem a strained conclusion to say that, in proportion as a navy develops skill in gunnery above that of other nations, it may afford to diminish the amount of protection of its ships and apply the consequent saving of weight in other directions. And again, the employment of cavalry offers so many striking analogies with that of torpedo boats that naval tacticians cannot fail to find the study of cavalry operations very suggestive.

Duties and capabilities of the Naval Brigade.—Prior to all discussion of details we must form a clear idea of what the Brigade may be called upon to do and of what it is able to do. An examination of the services of the Brigades of this and other countries during the present century will show that when the officers have been acquainted with military principles and the men armed and drilled as the soldiers of the time, their operations have always been creditable and usually successful, as in Maryland in 1814, in the Franco-German

war, and in Ashantee in 1873 before the arrival of troops; while on the other hand, failure to conform to recognized military principles has always been disastrous, as at Fort Fisher, and in Formosa in 1867. The actions in Formosa and Ashantee illustrate the necessity for the acquaintance of commanders-in-chief with military strategy; the others, the necessity for the use of proper arms and tactics by the men and officers.

From a consideration of the operations of the Naval Brigade it is seen that it has been able to operate on shore for a long time only when with an army with complete transport, or when transport and supply were furnished by the local means at hand. Two or three days is the limit of time for which a Naval Brigade may be considered independent. The organization of the staff, however, should provide for transportation and supply for as long a time as necessary when with the army or with auxiliaries. In regard to equipment, the forces should be armed with soldiers' weapons, never with the naval cutlass and pistol, and the personal equipment should be as light as possible. In regard to operations, the Naval Brigade has been called upon to fight against civilized enemies equipped and armed in the most recent manner; against half-civilized and savage enemies imperfectly armed; and finally, it has been used in street fighting and to suppress civil disorder, so that its proper employment in all these cases should be considered.

FORCES AT OUR DISPOSAL.

The forces which we have on shipboard are seamen, marines, engineer's-force, and non-combatants. The number and prominence of non-combatants in our service is entirely too great, and it is impossible to have a thoroughly effective navy when the best offers and rewards are made to men who are never trained to the use of weapons.

The engineer's-force forms a large part of every complement, and will be larger in the new ships. As the seamen are expected to be seamen and combatants, so the engineer's-force should be trained to the use of weapons, and should form part of the landing force; for when operating on shore, it would usually be that part of the complement which could most easily be spared from the ship.

There seems to be a growing impression in the service at large that henceforward the principal distinction between seamen and marines should be in discipline and uniform, not in different capa-

bilities and a division of duties. Already official reports speak of the entire efficiency of bluejackets as sentries and as infantry; and although the marines have always exercised at great guns, yet they must be made even more familiar with artillery, for they will no longer be able to stand on deck as riflemen opposed to the machine gun fire of modern ships. Fortunately they recognize this necessity and, as shown by their part in the discussion of a recent prize essay, they are ready to assume charge of the secondary battery and of submarine mining. It is evident that when marines and seamen can each undertake all combatant duties, the general efficiency of the service will be much increased.

REGULATIONS REGARDING LANDING FORCES.

There are no regulations or instructions in regard to the landing forces in our Navy. A commanding officer has perfect liberty with regard to the organization, drill, and tactics of his own force, and may equip it in any way he likes, using the weapons and stores furnished to his ship. It is true that Upton's Infantry Tactics are generally adopted throughout the service, but this is only because it is most convenient to conform to the usage of the marines; Mason's Artillery Tactics are simply "authorized for trial." In the Ordnance Instructions we find only "suggestions" which, however admirable in themselves, are as much out of place in such a book as suggestions would be on the part of a commanding officer under fire. If naval forces are to operate on shore it is essential for officers to have some knowledge of military affairs, and the Ordnance Instructions should indicate clearly and decisively what is required of a landing force in organization, equipment, drill, and tactics, and how much latitude in details is granted to commanding officers.

GENERAL REQUIREMENTS FOR LANDING FORCES.

Any plans adopted with reference to the Naval Brigade should comply with the following conditions:

1. The organization, equipment, instruction drill, and system of tactics on all ships should conform to a standard.

2. The tactical and administrative units should be small and should correspond, as far as possible, with the divisions on shipboard. This enables men to be always under their own divisional officers.

3. Permanent auxiliary bodies should be employed, as far as necessary, to prevent weakening the combatant units for non-combatant

service. These auxiliary bodies should have training and exercise in their special duties.

4. The organization should permit the ready combination of different landing forces, and should include about half the complement of the ship.

5. The force should be able to carry three days' rations.

6. The armament and equipment should be as much like that of the army as naval exigencies will allow; this applies particularly to ammunition.

7. A certain proportion of stores and provisions on every ship should be made up in small packages suitable for issue to and transportation by small forces.

8. Both officers and men should understand the tactical use of their weapons and have a clear idea of the performance of their duties, and in drill and instruction specified attainments should be required.

9. Petty officers should be granted authority and responsibility and assured position such as non-commissioned officers of marines now have.

RELATIONS OF LANDING FORCES TO GENERAL ORGANIZATION OF THE SHIP.

A large ship's complement is a necessary basis for an effective landing force. Four years of blockade against a much inferior enemy established the practice of undermanning our vessels; but as our new ships are masted and therefore presumably intended for general service, their complements should be large enough to provide against desertions and other losses and to admit of landing an effective force without destroying the efficiency of the ship herself. It is true that our ships have about the same complements as the English, but that service also has become accustomed to small crews by successes and by the necessity of maintaining the first fleet in the world with voluntary enlistments only. The complements of other nations are larger.

As the importance of the watch bill has been greatly diminished by the introduction of steam, it would seem advisable to make the quarter bill the basis of the organization of the ship's company. Officers and men after being once assigned to divisions should retain them permanently without regard to seniority or changes in the watch bill; and officers should be granted the control of the internal organization of their divisions, and should fill out the details of the various bills in

conformity with the general plans of the executive officer. The watch bill alone should be entirely in the hands of the executive. This plan would relieve the executive of much work and increase general efficiency.

The present system of messing is far from satisfactory, and when the landing force is disembarked the entire mess service is thrown into confusion. The system adopted on the training ships of issuing rations to the ship's company in bulk, and apportioning them when serving out, is much more economical, saves a number of mess cooks, and promotes cleanliness on the berth deck. It is as suitable to the requirements of the Naval Brigade as it is to those of the service in general.

One of the first requisites for an efficient landing force, as for an efficient man-of-war in general, is that no recruits should be allowed on board cruising men-of-war. Musketry instruction and field artillery exercises can only be carried out fully on shore; and it is strange that the system of training on shore which has given such good results for apprentices on the New Hampshire should not be adopted for all recruits in the service. This would require a longer term of enlistment to permit time for a cruise before discharge. To this long term of enlistment and training in barracks is greatly due the superior efficiency of the general body of marines on shipboard.

ORGANIZATION OF THE LANDING FORCE.

Hereafter, in this paper, the term "landing force" will be applied to the organization of the seamen and marines of a single ship for military duties on shore, "Naval Brigade" to a combination of landing forces, and "Brigadier" to brigade-commanders.

The unit of organization suggested in the present Ordnance Instructions is one which seems very suitable; it is small and may be readily divided into four parts, each of which is a convenient size for the command of a petty officer. The combatant unit should therefore consist of a company of 32 men, 4 petty officers, and either one or two commissioned officers, according to the ship's complement, but preferably the latter. This organization should act either as an infantry company or as a gun's crew, the men not required to man and drag the gun acting as its permanent escort and as a relief crew, according to the system of the Italian naval field artillery. The auxiliaries consist of the pioneers, cooks, medical force, signalmen, buglers, servants, and armorers. The pioneers should be drawn from the mechanics and

torpedo men, and should be in number one more than the number of companies in the landing force of the ship; the cooks should be as many as the pioneers. The medical force should consist of surgeon, apothecary, and two stretchermen for each landing force of one or two companies, and two more stretchermen for every two additional companies in the force. Two signalmen should go with every landing force, and a bugler with landing forces of two companies, or two buglers for larger ones. One servant for officers should be allowed for every two companies in the landing force, and one armorer for each landing force. One officer should be assigned to the command of all the auxiliaries. The whole landing force should be under the command of the executive officer, who should have an aide and the master-at-arms with him.

It should be an object as far as possible to have the ships' guns' crews of such a size that whole crews might be readily combined to form landing companies while preserving their divisional organization, leaving other complete crews on board for the defense of the ship. Crews of ten men for the lighter guns and of twenty for the heavier ones would form half and quarter companies, with one or two supernumeraries to fill vacancies. Each company should if possible be drawn entirely from one division, and be under the officer of that division. In a ship with eight 6-inch guns and two great-gun divisions, the full crews of four guns would form one company, and the other division would remain on board. The quarter companies would form convenient messes; all the members of each mess should be in the same watch.

In distributing the force among the boats, each half company of seamen and marines should have one boat with two boat-keepers assigned to it. The auxiliaries should have one or two boats each with two boat-keepers. Some of the launches carrying the guns will be large enough to take complete companies, but most of the artillery companies will be divided like the infantry.

The spare room remaining in the boats should be occupied as necessary by men intended to remain on the beach to throw up defenses and prepare for re-embarkation, giving an average of about twenty-five to thirty men to each boat. The boat-keepers and the other men to remain on the beach should belong to one company or platoon accustomed to act together under their divisional officer, who should be the beach-master.

NAVAL BRIGADE.

Infantry.—On forming a Naval Brigade out of several landing forces, the infantry should be formed into divisions of two companies each, under the senior of the two company officers, still preserving the company organization, and then into battalions of three divisions each (6 companies), each battalion under the command of the executive officer of a ship, who will be accompanied by his aide and the master-at-arms. The marine companies should be formed into battalions by themselves, but as for the rest, it should be the endeavor to associate companies from one ship in the same division, and divisions from one ship in the same battalion.

The auxiliaries should be divided among the battalions, and to that end each pioneer, cook, etc., should regard himself as attached to a certain company, so that on following it to its battalion he would find there the rest of the auxiliaries necessary to complete that battalion. In this way every battalion would be complete in itself, forming a force of 216 rank and file, 30 to 40 auxiliaries, and from 10 to 16 officers, preferably nearer the latter number (battalion chief, aide, surgeon, officer commanding auxiliaries, and 6 to 12 company officers). The auxiliaries would vary a little in number in the different battalions according to the way of combining the landing forces. If the battalions are numerous enough, they should be grouped together in fours, forming commands of about 1080 men. The total force out of the ships including boat-keepers and beach force would probably average about 318 men for each 6-company battalion.

Artillery.—The guns should be formed into divisions of two guns each, and then into batteries of 4 or 6 guns each, according to the total number. The machine guns should be kept separate from the field guns if there are enough in all to form two or more batteries. The batteries should have the same proportion of auxiliaries as the battalions, and a six-gun battery would therefore be of exactly the same strength as a battalion.

As battalions and batteries are fixed in organization and each is complete in equipment, their chiefs should relieve the brigadier of responsibility in many details and so facilitate despatch in preparing for service. On organizing landing forces into a brigade, the officers attached to them will always be numerous enough to furnish the necessary number for the higher commands and their respective staffs without recourse to additional officers.

The brigade staff should consist of an adjutant, a quartermaster

and commissary, a surgeon and one or two aides. The adjutant should be the chief of staff, issuing necessary orders and making all details for guard duty, assignments to quarters or camping ground, etc. He should issue the orders for marches, and be responsible to the brigadier for the execution of all his directions. He should have a writer to receive and take charge of the daily battalion reports and to make out the daily brigade reports for the brigadier and to keep the brigade log. The quartermaster and commissary should have charge of all hired or impressed labor, of pack animals and teams, and of the purchase and transport of all stores and supplies except those carried by the force itself for immediate use. He should have under him an officer to assist him in issuing clothing and provisions, in paying the men, and in keeping the necessary accounts. He should be further aided in his duties by a detail of officers and petty officers, according to the size of the force and its probable length of service. The brigade surgeon should be entrusted with the general direction of the medical force and of sanitary regulations and inspections, and should be consulted as to the location of quarters and camping grounds.

If the stay on shore is to be for more than two or three days, it will be necessary to provide for a system of returns and accounts. For this purpose each company-chief should be provided with a suitable pocket blank-book, containing a few pages for the daily journal of his company, showing the work done by his force, its details, and casualties, and orders received and issued. Other pages should be for a daily report of effective strength to the battalion-chief, similar to the report of the marine guard daily submitted to the commanding officer on shipboard, and others still should be for requisitions. On landing for long periods, the pay account of each man should be furnished to his company-chief, who should draw on the quartermaster when he desires to pay off. All requisitions, as well, should be made out by company-chiefs and issued through them. All the requisitions should be presented to the battalion-chief, and upon approval, the quartermaster should issue to the company-chiefs, who should make the distribution. Battalion and battery chiefs should have authority equal to that of commanding officers of ships in regard to the purchase and issue of stores.

Covering Force.—The organization of the covering force of ships and boats should be distinct from the brigade. No landing force should be sent from the covering ships, for if the object is not a dis-

tant one, their work will be very severe and require all hands. The artillery of the brigade will usually form the covering force of boats, but in case there is an abundance of boat artillery the covering boats should form a separate division.

Brigade Organization.—The following table shows an organization of a brigade from ships with full war complements, instead of the present ones:

Name of Ship.	Total complement.	Landing Force.		
		No.	Boats.	Organization.
Chicago............	500	262	10	1 Machine gun, 1st battery; 1 company marines, 1st battalion; 4 companies seamen, 2d battalion.
Charleston........	500	262	10	1 Machine gun, 1st battery; 1 company marines, 1st battalion; 4 companies seamen, 3d battalion.
Lancaster.........	450	222	8	1 Machine gun, 1st battery; 1 company marines, 1st battalion; 3 companies seamen, 4th battalion.
Boston.............	380	179	7	1 Machine gun, 1st battery; 1 company marines, 1st battalion; 2 companies seamen, 2d battalion.
Atlanta............	380	179	7	1 Machine gun, 1st battery; 1 company marines, 1st battalion; 2 companies seamen, 3d battalion.
Galena............	275	139	5	1 Machine gun, 1st battery; 1 company marines, 1st battalion; 1 company seamen, 4th battalion.
1700 ton vessel..	200	96	3	1 R. F. gun, 2d battery; 1 company seamen, 4th battalion.
Nipsic.............	160	96	3	1 R. F. gun, 2d battery; 1 company seamen, 4th battalion.
870-ton vessel...	125	52	2	1 R. F. gun, 2d battery.
Despatch..........	95	52	2	1 R. F. gun, 2d battery.
Total............	3065	1539	57	

1st battery, 6 machine guns; 2d battery, 4 R. F. guns. 1st battalion, 6 companies marines; 2d, 3d, and 4th battalions, 6 companies each of seamen. Naval Brigade 1539; total force out of ships, including boat-keepers and beach force, about 1800.

EQUIPMENT.

Under this head will be discussed arms and combatant equipment, clothing and other personal equipment, and general supplies carried for the force. While the plan of organization may and should be

the same on all occasions, supplies must vary greatly according to the probable duration and nature of the service, and the armament will depend somewhat upon the nature of the service.

ARMS.

Every enlisted man in the landing force should always be armed with the service rifle and bayonet. Cutlasses are fit only for mounted men; in most armies cavalry and artillery leave them on their horses when dismounting. Pistols and revolvers are too dangerous, and are worthless at any but the closest ranges.

Bayonet.—The bayonet is a great moral support in every action even if not actually used, for it is always the tactical object to come to close quarters and decide the matter. If a man has a side arm in whose use he is skilled he will attack more boldly and advance farther than if he were without it; our bluejackets, therefore, cannot afford to dispense with it.

Rifle.—The principal defect in our present service rifle is that it lacks flatness of trajectory. In modern naval combats, the range, after it has been ascertained, will vary so fast that when the sight is adjusted it will no longer be even approximately true, and a well aimed bullet will pass over or under the point aimed at. It is therefore very important to flatten the trajectory as much as practicable, causing it to coincide more nearly with the line of sight and thus increase the limits of range within which a well aimed shot with a given sight elevation will strike a target of a given height. With our present rifle, if the sight is adjusted for 400 yards and the enemy approaches upright and aim is taken at his feet, the bullet will never rise above the height of his head, so that he will certainly be hit by a good shot at any range under 400 yards. In the case of two charging ships it will be useless for riflemen to endeavor to pick off adversaries at greater ranges than this limiting one of 400 yards; for aiming would be the merest guess-work on account of the rapid change of range. It is possible, however, to flatten the trajectory so that at the 600 yards range the bullet will not rise above a man's height, and it is apparent that such a trajectory increases by 50 per cent the time available for small arm fire between two ships (if the aim is very good). The advantage of the flat trajectory is equally apparent on shore, for it is very difficult to cause men to pay attention to the sights at the close ranges, and the flat trajectory increases the limits of range within which the sights may be neglected, and at the greater ranges

permits of an equally effective fire with less accuracy in the estimation of distances. The only practicable way of flattening the trajectory consistent with other requirements of a military small arm is by decreasing the calibre, and the nations of Europe are re-arming with reduced calibres or are experimenting in that direction. England was armed with 45 calibre and experimented down to 35, but adopted 40 for her re-armament, being led to sacrifice flatness for a small increase in accuracy of the larger calibre.* The advantage in preferring this slight increase in accuracy is very doubtful, for the errors due to the imperfect estimation of ranges and the exhaustion and excitement of the marksman are proportionally so large that the shooting on service would not be perceptibly improved even if the rifle were absolutely free from deviation. A decrease in calibre entails a reduction in the weight of ammunition, thus enabling larger supplies to be carried.

It is a matter of some importance that the Army and Navy should use the same cartridge, and as it is said that the Army is considering the propriety of reducing the calibre of the Springfield rifle, it is to be hoped that the Navy may considerably reduce the calibre of its rifle and arrange with the Army to adopt the same cartridge. The adoption of the magazine rifle by the army of Germany and the army and navy of France, and the postponement of the English re-armament in order to adopt a magazine rifle, as well as our own experience, render it clear that the magazine rifle is better than the single loader both for military and naval use.

Artillery.—The field and machine guns employed should be such as are suitable for use on board ship as well. The three-inch howitzer is effective on account of its large calibre, but it is of too low a power in proportion to its weight and mount for present use, so I am inclined to choose between the revolver-cannon, the rapid-firing gun, and the small-arm calibre machine gun, all of which are ship's guns. For use on shore the revolver-cannon offers no advantages over the rapid-firing gun, for its faster discharge is of no importance, as time must be allowed to see the result of each shot. The rapid-fire gun and the small-arm calibre machine gun should form the artillery of our landing forces, and the circumstances of each expedition should decide which to employ or in what proportions. The artillery carriages should have large wheels with broad tires to diminish the

* Her re-armament has been delayed, and she is now experimenting with a 31 calibre.

drag when moving them, and should have shafts for use when animal transport can be procured. In selecting a field gun, the limit imposed is one of weight. As it is proposed to use half companies as gun's crews with the other half companies as escorts and reliefs after the Italian fashion, we have 18 men to man the drag rope. The French allow 167 pounds and the Germans 145 pounds to each man, and in tropical India the English have found that 190 pounds is not excessive. Taking the mean of these amounts we find that 3000 pounds is a full load for our crew of 18 men, and that the high powered 57-mm. (6-pounder) Hotchkiss gun with limber and 50 rounds, weighing in all 2422 pounds, is well within the power of a half company; but the objection to it is that the supply of ammunition is too small, and an extra box of ammunition, containing only 14 rounds, weighs 176 pounds. A limit of not much over 2000 pounds, however, would be more generally acceptable, and such a weight could be taken almost anywhere. As the gun should carry some of the arms and equipments of its crew, we thus have the choice between the high-powered 37-mm. Hotchkiss rapid-firing gun with limber and 80 rounds, weighing 1555 pounds (extra boxes with 24 rounds weigh 88 pounds), and the low-powered 47-mm. Hotchkiss rapid-firing gun with limber and 105 rounds, weighing 1405 pounds. The great advantage of a flat trajectory is certainly with the 37-mm. gun, but on the other hand, a large calibre is desirable for field guns rather than penetration; and besides, 47 mm. seems to be about the smallest calibre for effective shrapnel fire. For this reason, of the two, it would be better to select the low-powered 47-mm. gun, or perhaps even to exceed the 2000 pounds limit, and employ the high-powered 47-mm. gun with limber and 72 rounds, weighing 1975 pounds. If, however, animal transport can be obtained, the 57 mm. should always be used on account of its large projectile. The equipment for the rapid-firing guns should consist of a limber carrying the ammunition and the necessary racks and arrangements for carrying the arms and part of the equipment of the gun's crew (see Vol. 30, R. U. S. Inst.), as will be described under Personal Equipment.

Machine guns mounted according to the plan of Colonel Alt, of the Central London Rangers, can carry 5000 rounds with a steel shield, and the rifles of its crew, on a weight of 1120 pounds (see Vol. 30, Journal R. U. S. Inst.); by removing the steel shield and adding a limber of 400 pounds, a total of 8000 rounds may be carried on the same weight as that of the rapid-firing gun.

It is urged by Colonel Alt that the supply of 5000 rounds is sufficient, and the experience of the Soudan is cited where the maximum expenditure in a day of severe fighting was 1300 rounds. But against civilized forces the expenditure would be much greater, for the machine guns would probably be used as far as possible to replace the long range infantry fire, and the expenditure of ammunition would therefore be very large; and these guns would besides furnish the reserve ammunition for the infantry. Both rapid-firing and machine guns should each carry 1 hatchet, 2 bill hooks, 2 picks, 2 shovels, total weight 20 pounds, and a range finder to each two guns (or 2 pounds for each two guns). Each gun should also be provided with a prolonge, so that the crew may pass beyond bad ground and then haul the piece through.

Entrenching Tools.—Entrenching has become such a necessity for defense against modern fire that entrenching tools have reached the dignity of defensive weapons, and they should be issued to ships as a part of their equipment. It would not always be necessary to land them, but when this is done every man in the ranks should carry one and should never part with it under any circumstances. The Wallace entrenching tool, combining pick and spade, and weighing 2 pounds 6 ounces, has been thoroughly tried and has proved excellent. In regard to the amount of ammunition to be carried, 100 rounds for the infantry cannot be considered too much, for 120 to 150 rounds have frequently been expended in action, necessitating re-supply during battle. For the artillery and the rest of the force 40 rounds would be enough.

Personal Equipment.—The uniform for landing should be as ordered; blue flannel is best for general use. It is necessary to carry only articles for immediate use, for if the force is to remain ashore for a considerable time, transportation for clothing, food, and supplies must be found on shore. Besides his arms, each man of the landing force should carry with him half a shelter tent, a rubber blanket, a woolen blanket, ammunition belts, a water bottle, a knife, and a haversack containing cooked rations and fork, spoon, plate and cup, with little conveniences such as soap, tooth brush, needle and thread, etc. Leggings should be worn. The blankets, clothing, and tent should be rolled and secured on the back by straps like a knapsack, for the horse-collar roll is very uncomfortable. The weights carried by an infantry man are thus: clothes worn, 7 pounds 6 ounces; rifle, 9 pounds; bayonet and scabbard, 1 pound 3½ ounces; ammu-

nition (100 rounds), 10 pounds; waist belt and two ammunition cross belts, 13½ ounces; water bottle filled (1⅛ pints), 2 pounds 10 ounces; mess-tin, complete, 1 pound 9 ounces; haversack, 4 ounces; knife and lanyard, 6 ounces; hold-all containing housewife, comb, tooth brush, towel, fork, and spoon, 14 ounces; field dressing, 2 ounces; half shelter tent, 2 pounds (rifles answer for tent poles); rubber blanket, 2 pounds 8 ounces; blanket, 3 pounds 7 ounces; entrenching tool, 2 pounds 6 ounces; 3 days' cooked rations, 8 pounds 4 ounces; total, 51 pounds 8 ounces. The overcoat will not always be needed on an expedition; its weight is 4 pounds 8 ounces, bringing the total when it is carried up to 56 pounds. For artillery men and all others the weights will be the same, except 40 instead of 100 rounds of ammunition, making the total 45 pounds 2 ounces, but when actually dragging a gun or carriage they will carry on the gun or carriage their rifles, bayonets, entrenching tools, tents, both blankets and rations; total, 28 pounds 14 ounces. The total weight carried on the gun for a crew of 18 men would thus be 520 pounds.

The mode of carrying the small arms on the carriage is clearly shown in the lecture on machine guns by Captain Armit (Vol. 30, Journal R. U. S. Inst.), and is an improvement on the beckets suggested in Par. 824, U. S. N. Ord. Inst. According to this plan gun racks were placed over the axles; the bayonets should be fixed. The tents and blankets weighing about 144 pounds, and the rations weighing as much more, could be carried underneath the axles of the limber and body where there would be plenty of room to place boxes containing them, making the total weight of the low-powered 47-mm. gun 1925 pounds, and of the high-powered 47-mm. gun 2495 pounds.

Officers' Equipment.—Officers on landing service should wear the service uniform; the undress frequently worn when the men are in marching order is very unsuitable. Their equipment should consist of a large calibre revolver loaded, with a spare round, or 12 cartridges in all; binoculars, small compass, note book, with pencil, watch, map of country, haversack containing three days' rations and hold-all with comb, tooth brush, soap, clothes brush, needles and thread; field dressing, matches, mess-tin with fork and spoon, knife with lanyard, water bottle, half shelter tent, rubber and woolen blankets, towel; total 35 pounds 11 ounces. Overcoat 6 pounds 8 ounces, making, if it is carried, a total of 42 pounds 3 ounces.

Transportation.—There should be a certain amount of transport for every battalion and battery, which should be provided in the form

of a carriage composed of two limbers coupled together and manned by the auxiliaries of the battalion. Shafts for animal transport should be provided, and the carriages should be fitted for carrying the following articles:

Articles.	Number.	Weight (Pounds).
Axes,	6	35
Hatchets,	3	6
Bill-hooks,	5	10
Pinch-bar,	1	10
Picks,	10	38
Shovels,	10	28
Handsaws,	4	8
Small arm tools (set),	1	4
Marlin spike,	1	
Grease,		10
Spun yarn,		
Soft iron wire (30 yards),		
Box for above,	1	50
Gun-cotton outfit including battery, wires, 50 pounds of g. c., detonators, and 3-inch auger,		90
Stretchers (3 pair) and Surgeon's chest,		75
Signal kits,	2	20
Kits of dragmen,	18	520
Mess kettles (in nests),	10	85
Range finder for infantry battalion,	1	2
Total,		991
Carriage (body and limber)	1	800
Total,		1791

If thought necessary, two boxes of ammunition (2000 rounds) weighing 220 pounds might be added, making a total weight of 2011 pounds.

Transport.—Although the weight of 51 pounds is less than that carried by the infantry soldiers of most nations, it is worth considering whether, for sailors, it would not be well to furnish transport even on the shortest expeditions for a part of this personal equipment whenever it is required. Of course, no man should part with his arms, but his haversack, mess-tin, three days' rations, half shelter

tent, blanket, rubber blanket, and hold-all, amounting to about 19 pounds 4 ounces, might well be carried for him.

If this course should be adopted, limbers at the rate of one to each company would be sufficient. Each limber should have a keeper, and when coupled together each pair should weigh about 2500 pounds loaded, and should carry the arms of the men hauling it, besides the other baggage. In this way, a detail of three half companies from each battalion would haul all its baggage. The transport of the baggage of half the artillery has already been provided for, on the pieces, so that one limber for every two pieces would be enough; thus, in a six-gun battery at any one time there would be eight half companies at the drag and four as escort and relief. The baggage should be packed under its keepers whenever an action is expected. These keepers would raise the total of a battalion by six men. Of course horses should haul all the baggage whenever possible.

The equipment described is sufficient for a force entirely independent of external resources, but there are only three days' cooked rations and the camp kettles are only fit for making coffee. If the expedition is to be longer, it will be the duty of the quartermaster and commissary to estimate and provide the necessary amounts of stores and transportation according to the means at hand. The first necessity is food, which must be provided as required. Pots, kettles and boat-stores should also be provided. Then clothing and shelter should be thought of. The spare clothing of each man should be carried in a bag marked with his name, and the clothing of each company should be put in large company bags. Small stores and new clothing should also be transported when on long expeditions. Tentage should be provided only when a particular point is to be occupied for some time; when constantly moving, shelter tents carried by the men are enough. With the tentage should be carried a sufficient supply of brooms and rakes for keeping the camp grounds in order, and buck-saws for cutting firewood, and, above all, the reserve ammunition should be abundant. It is impossible to predetermine the nature of the transportation; it may be by bearers, pack animals, or teams.

TACTICS.

To secure efficiency in the duties of landing forces all recruits should be shipped in the United States and sent to barracks, where they should be divided into small groups under the care of petty

officers, who should be responsible for their instruction and general behavior. In all instruction it should be the object to attain definite specified results, so that men acting together even for the first time would have the same knowledge and ideas regarding their duties; but the methods of instruction should be largely in the hands of the officers in charge. Uniformity in the manual of arms and in the performance of manœuvres should be strictly enforced; it is too common to see officers point with complacency to changes they have introduced, which, however admirable they may be in themselves, prevent uniformity in exercises because they are in contravention to the custom of the service which has accepted the army infantry tactics as its standard.

It is greatly to be desired that the entire control of ships in commission should be committed to a single bureau which should issue full instructions on every point of drills and exercises, and enforce them by means of a staff of inspectors. As an example of such instructions may be mentioned the English *Rifle and Field Exercises and Musketry Instructions for H. M.'s Fleet*, and the French *Manuel du Marin-Fusilier*, the latter a book of some 600 pages, of which half is devoted to the instruction, exercises and duties of small-arm men in ship fighting, and the rest to the infantry of the landing force.

The recruit should be taught a soldier's duty progressively, as in the army. He should learn the school of the soldier, how to march and face, and the manual of arms. The manual of the English service is far more suitable for the unconfined habits of seamen than the one of our own army. It was adopted with one or two slight changes by the force at Panama in the spring of 1885, and the results were very satisfactory. Bayonet exercise should be taught, for it is now more important than cutlass drill. The French employ riflemen boarders, and it is noticeable that in the majority of successful attacks (on shore) in recent years the result has been decided by actually crossing bayonets, except when the defenders' ammunition has been prematurely exhausted. With regard to manœuvre tactics or the evolutions for transferring troops from point to point, Upton's tactics are perfectly satisfactory.

Target Practice.—When some proficiency in these exercises has been obtained, the rifle firing instruction should be commenced. In the army a certain sum per annum ($7.50) is allowed for each man's target practice, and careful company commanders can get as much as 1500 shots out of this amount. The army manual for rifle firing

recently issued to the Navy is admirably fitted to secure good individual shooting. In following its course, the recruit begins with some theoretical and practical instruction in sighting; he next goes through position and aiming exercises to teach him control of himself and his muscles, and may then begin gallery target practice with reduced charges and spherical bullets. After all these preliminaries the pupil begins practice with service ammunition at short known ranges, for which longer ones are progressively substituted. During all this time the estimation of distances under varying circumstances of weather and locality is taught, and finally skirmish practice upon targets at unknown distances is undertaken, together with volley and file firing and with running or disappearing targets. To secure general interest in shooting, a series of competitions are annually held and prizes are awarded. The results of this system in increasing individual skill in matches with the service small-arm have been very great; but it seems to be assumed that the average of individual efficiency with fire-arms is the measure of the efficiency of the army in battle. In this assumption our army has followed the English, which has recently begun to waver in its belief; while for many years past this idea has been totally rejected by all the continental armies of Europe, and the weight of evidence is greatly in favor of their opinion. They state that with individual fire, it is directed upon so many objectives and the errors in estimating the ranges are so great that its useful effect is very small. In addition it has been found that with uncontrolled firing the excitement is so greatly increased, that once begun it is impossible to stop or even check the expenditure of ammunition until the last round has been fired; in the meantime no orders can be heard, the troops cannot be pushed forward, and so the ammunition is wasted at the least effective ranges. For these reasons continental nations regard individual target practice as merely preliminary, and further practice is directed towards obtaining good collective shooting, while maintaining the strictest control over the fire by permitting only volleys, or a small stated number of rounds in file firing. In this way opportunities are afforded for passing orders, for permitting the smoke to clear and for watching the effect of fire; the waste of ammunition is prevented, and when close quarters are reached and the men finally escape from control, they have still a reserve of ammunition and their individual fire is effective at the short ranges which have been reached. It is besides the object of continental target practice to furnish rules to the leaders

so that they may have definite ideas as to the amount of ammunition which may be properly expended at any moment for the attainment of a given object, and also that they may know how to produce the best effect from a given expenditure.

Battle Firing.—The rules governing the employment of individual fire are based upon the accuracy of the knowledge of the range, upon the flatness of the trajectory of the rifle and upon its accuracy; or upon the size of the target which will catch all or any given proportion of the bullets fired at it at varying ranges.

To understand these rules, it is necessary to define the term "dangerous zone," which is understood to be the space at the end of the descending branch of the trajectory where the height of the bullet above the ground is less than the height of the target. The dangerous zone for a group of shots fired at the same point is somewhat greater, for it is increased by the dispersion of the group. It is therefore an object to have the trajectory as flat as possible in order to decrease the angle of drop and so increase the dangerous zone. The effect of the dispersion of bullets is to set a limit upon the range at which individual fire may be usefully employed. It has been found that with ranges exactly known a very good shot may put 22 per cent of shot in a standing man at 600 yards, and 27 per cent in a group of four men at 1100 yards. It is thus apparent that in war, when results are estimated at one tenth of peace practice, the limit of range at which individual fire can be permitted is soon reached even when the ranges are exactly known.

When the ranges have to be estimated, as is usual in war, it has been found that the probable error in either direction in the mean of the estimates of several practiced observers is $\frac{1}{8}$; that is, the probable error in both directions is $\frac{1}{4}$. It is readily seen that when the probable error, or $\frac{1}{4}$ the range, is greater than the dangerous zone of a group of shots for that range, it is not advisable to fire. This range for the service rifle of most countries is about 500 yards. At ranges of 400 yards and less, the trajectory never rises the height of a man above the line of sight, so that the entire space up to the muzzle is included in the dangerous zone; and the Germans therefore employ a sliding-leaf sight for long ranges, a flap sight set for 400 yards which requires no alteration for use against standing troops anywhere under 400 yards, and a fixed sight set for 300 yards which is good against a kneeling man at any less range. The advantage of this arrangement of sights is that it simplifies their adjustment and so improves the

shooting in the great excitement of close ranges. To further improve the shooting, it is the custom abroad to aim at the foot of the target, because it affords the most distinct mark; because men are liable to fire high, and because many of the "short" shots will ricochet effectively, whereas "long" shots are wasted.

In determining the limits of range to be set for the use of collective fire, the change from the conditions of individual fire is in the accuracy or the size of the shot group. It has been found that in collective fire the area containing all the bullets fired at a given target is rather uncertain, but that half the bullets fall in a fairly constant depth which does not vary much from 100 yards at any range under 1500 yards, and is known as the "beaten zone." The width of ground beaten by a group of shot varies from about 15 feet at 550 yards to 120 feet at 2650 yards, and the rules for the use of collective fire are formulated with the idea of utilizing this best 50 per cent of shot. The efficacy of collective fire at any range evidently depends upon the width of the beaten zone and the depth of the "dangerous zone" of each bullet for that range, and it has been calculated that a collective fire directed at a small target at 500 yards is twenty-four times as efficacious as at 1700 yards. For this reason it is believed by most continental nations that collective aimed fire cannot give adequate results over 1300 yards. If, however, the supply of ammunition is superabundant, as with the Turks at Plevna, a very great expenditure by unaimed or "chance" fire may give important results.

When the range is such that the probable error in its estimation is greater than the depth of the beaten zone it is improbable that the fire would be effective, and two or more sights, differing from one another by the depth of the beaten zone (or 100 yards), should be employed in order to form a beaten zone large enough to cover the probable error in the estimated range. For this reason numerous range finders are necessary in order to decrease the errors in the range; for if estimation is relied upon, to be certain of striking the target at 1200 yards, the beaten zone should be 300 yards deep, requiring three sights, and so decreasing the efficacy of the fire at any given point; whereas if the range were ascertained within $\frac{1}{12}$, a beaten zone of only 200 yards depth would be required at the same range to cover the error of $\frac{1}{12}$ in either direction and so the fire would be greatly increased in efficacy.

The slope of the ground has a great influence upon the useful effect of fire, for the depth of the dangerous zone of each bullet, as well as

of the beaten zone of the group of bullets, evidently depends upon the amount and direction of the slope; so that if troops are known to be concealed behind the crest of a hill, the fire against them may be more effective than if in plain sight in front of it. If troops are in close formation the slope of the ground is important, because it affects the virtual height of the target presented to the enemy.

CONTROL OF COLLECTIVE FIRE.

In order to retain the direction and rapidity of fire under the control of the leaders and officers of the firing line, it has been found best to fire by volleys. As the opposing lines approach each other the excitement causes the men to tend to escape from control, but it is still possible for skillful leaders to substitute file firing for not more than three rounds, with pauses in which sights can be readjusted and orders passed; finally, at the close ranges under about 400 yards the best disciplined troops escape from all control, and their fire becomes rapid and continuous until the supply is exhausted or the battle decided. At long ranges a single officer can direct the fire of a large body of men, but as the ranges decrease control becomes more difficult, and the company commanders turn over the direction of fire to the subalterns, and these again to the non-commissioned officers, who direct their little groups of fire-units or ten to fifteen men up to the very crisis of the action.

In the employment of this group system lies the essence of the battle tactics of the continental armies; it has also been adopted as the basis of the organization of French naval landing forces.

Group Formations.—If large bodies of troops are pushed to the front to reinforce other large bodies, the commands are intermingled and confusion ensues. The only way yet found to mitigate this confusion has been to push forward small complete groups in the intervals between other small groups, and to teach men separated from their commands to act with the nearest group, attaching themselves to rank rather than to personality; and it is on account of their responsibility as group leaders in battle that good non-commissioned officers are indispensable to good armies.

BATTLE FORMATIONS.

A close formation is the one which renders manœuvring most easy and gives to the leaders the best control over the fire; but it is too vulnerable, and as the enemy is approached it is necessary to

open out more and more to avoid excessive loss. The system of attack adopted by the continental powers may be described as an extended line supported by successive lines of closed bodies of increasing size.

The following summary, from a pamphlet by Colonel Jayet, of the French army, will indicate with sufficient clearness the tactics of a small infantry force advancing to attack. It must be explained that the force in question, a French company of 200 men, is divided into four sections of four squads each, and the company column is a column of sections. The artillery having taken up a position 3300 yards from the hostile artillery, prepares the advance of the infantry; and when the enemy has been sufficiently shaken by the artillery, the infantry, which has been formed in its rear, advances in company columns, each company presenting a front of 25 files or 20 yards, and a depth of 13 yards. Artillery is able to place half its projectiles at a range of 3300 yards on a rectangle whose width is three yards, and each projectile gives 100 to 150 fragments; it will therefore be necessary to take the battle formation at 2750 yards at the very latest. The captain will throw forward the first section, and the other three will shelter themselves in its rear from the enemy's view. The front of the section being twenty yards it offers too large a target, and its officer will be obliged to divide it into squads, or the men will certainly do so without orders at the first shell which reaches them. The small size of the squads and rapid marching will enable the section to reach 2200 yards without deploying; but an examination of the results of target practice will convince any one that, except in specially favorable ground, it cannot go further without deployment. Infantry inflicts a loss of three per cent at 600 yards on a skirmish line with 5½ yards intervals, and it may be assumed that if it does not halt, a skirmish line deployed at 2200 yards, composed of good soldiers boldly led, may reach the distance of 1320 yards from the hostile artillery, or 660 yards from the hostile infantry, without great loss and in good spirits; but this zone can be crossed only on condition that the skirmish line does nothing but advance. Its object while in this zone must be to reach a position whence its fire may be embarrassing to the enemy, if not efficacious. It must not stop to fire; every moment of halt is time lost, which can only tend to demoralization; the results of fire can be nothing, for distances are unknown; the enemy knows them, and is sheltered, and against a single section he opposes two or three.

As the interval in the skirmish line cannot be decreased without too great loss, it is apparent that so far there must be no reinforcements; on many grounds even this interval of 5½ yards is much too small. When the skirmish line has reached this distance (660 yards from the hostile infantry) the reinforcement, sheltered by its fire and hidden by its smoke, may come up; it will now be useful in the firing line. The company cannot be hurried further; it must gain ground, but there is no fixed rule to follow; the line must advance firing and availing itself of the ground.

A captain who leads his company well will arrive within 330 or even 275 yards having engaged only two sections; with the third he may make another 110 yards. If he is fortunate he will get within 110 yards and assault with his company only, but this will be the exception; more frequently he will need the help of the battalion reserve.

The other three sections were left behind at 2750 yards from the enemy's artillery; they will advance sheltered by the skirmish line, and in favorable ground they will sometimes be able to help the latter by their fire. The column formation must be abandoned at 2750 yards from artillery, and the reinforcement composed of the second section grouped in squads will follow the skirmish line at 165 yards distance. In this formation this line may approach within 1100 yards of the hostile infantry, for its circumstances differ from those of the skirmish line; it must follow the latter, but it may choose the moments for advancing, and by rushes of 50 yards and kneeling it may move on without much loss. The ground must be favorable for this line to advance further than 1100 yards without deployment, as the fire of the hostile infantry is becoming serious. The reinforcement will therefore deploy at about 1100 yards and form a second skirmish line, and so can remain without demoralization until the first line commences firing, when it moves up and joins it. The other two sections (the support) on passing their artillery will form with an interval between them on the same line, and by the shelter of the two lines in front and by taking cover and kneeling this support may follow the second line at a distance of about 165 yards until it is about 2200 yards from the hostile artillery, when it will probably be compelled to form into grouped squads. It may thus reach a distance of 1100 yards from the hostile infantry, when the leading line will become engaged; the fire and smoke will facilitate the advance of the rear lines, and will permit them to reinforce the first line when necessary without changing the squad formation. As the second and third lines join the

firing line they push it forward by the impulse they communicate, and finally, when the firing line is near enough, it assaults with the bayonet.

BATTALION FORMATION.

In the French battalion formation, in which the battalion corresponds to the four-battalion organization above described for the Naval Brigade, two companies are usually deployed as above, and the other two form the reserve which follows the third line at about 165 yards distance, opening out as the enemy's fire requires it. When the supports have been absorbed in the firing line, the reserve is also sent forward until the line is dense enough to assault, or in case of a retreat it is deployed to oppose the enemy while the fighting line reforms behind it.

Battle Formation for Naval Brigade.—Upton's deployment of a fighting line by numbers was adopted in the U. S. Army (in 1867) before the recent great wars; it has never been tried in battle, and its unwieldiness and lack of cohesion are in complete opposition to the requirements which have been satisfied by the group formation described above. The group unit for the Naval Brigade should consist of a half company or 16 men and 2 petty officers, who should be kept together both when closed and when deployed. Each four should also be regarded as a permanent organization, the men always falling in in the same order, and each vacancy should remain, the rear rank man stepping into the front rank, or should be filled by a new man from the company's gun division. Upton's company deployment by the flank is based upon the group formation, and is perfectly applicable to our naval companies thus organized. A naval battalion should be deployed and manœuvred similarly to the French company whose motions are described above. For instance, if a battalion is to take its fighting formation, two companies would form the skirmish line, two the reinforcement, and two the support. On arriving within range, the leading companies will take an interval sufficient for deployment, and later will separate into half companies; the latter will finally deploy into the skirmish line as they advance, and will endeavor to keep in their original groups. The reinforcement and support will throw their half companies in groups into the skirmish line when the time arrives.

DEFENSE.

On the defense, fire is opened earlier than when attacking, in order to compel the early deployment of the assailants, whose advance is

retarded and whose mistakes are less easily rectified when in open order. The formations are substantially the same as when attacking, except that the supporting lines are kept nearer the fighting line. The fighting line is gradually strengthened by the advance of the supports, until only a reserve remains in rear to deliver a counter assault and pursue the enemy or to cover the retreat as the case may be. The greatest losses usually occur during a retreat under fire.

MANŒUVRING ADVANTAGES OF SMALL FORCES.

Small independent forces have much greater freedom on the battlefield than large ones. Small detachments are unembarrassed by forces on each side obliging them to move straight forward, so their rear lines can outflank the first line, thus making a flank attack on the battlefield; large forces can arrange for a flank attack only when off the battlefield. Artillery has freer choice of position with small forces.

REFORMING ENGAGED TROOPS.

"The necessity of reforming engaged troops as soon as the engagement ceases or during any pause in the fight is so great in these days of fighting in extended order against an unseen enemy hidden by cover, that it cannot be too strongly impressed on leaders of all ranks. It is only by so doing that command, control, and cohesion can be maintained, the evil caused by the mixing of the larger units reduced to a minimum, and the moral effect of numbers impressed on the men, who are apt to think their losses greater than they really are. Reforming the tactical units also has the effect of rendering the men available for use in other directions, which they were not before, and of having them as completely in hand as possible to meet any further attempts of the enemy. These remarks apply equally to attack and defense."*

SAVAGE WARFARE.

"It may be considered that fire discipline, direction and control are not required in small wars against savage or undisciplined nations. This is a great mistake; the nature of the enemy and his weapons may govern and change our tactical formations, but never the fire discipline, direction and control, which alone can assure the fullest efficacy of the fire being attained under any conditions. With an enemy unarmed with modern weapons or unskilled in their use, closed formations may be retained from the great advantages of the control

*Mayne's Infantry Fire Tactics.

and the moral support they give the men, and volleys may be used up to a much shorter range, but otherwise the fire tactics described in the foregoing pages can alone develop the full efficacy of the fire."*

BUSH FIGHTING.

In regard to bush fighting Lord Wolseley says: "Considerable method is required by all commanding officers in bush fighting; if there is hurry, your force gets cut up into several parts without any connection between them, and it is difficult to collect them again for any concerted action. In no sort of warfare is it more essential to have a small reserve kept intact up to the last moment, for it is impossible to see what your enemy is about or to know where he is until his attacks have actually developed themselves, and panics are more probable in a dense forest than in an open country. Teach your men to go into the bush, there is no use in lying down and firing; the savage is perhaps better at that game than you are, your only safety is to go straight at your enemy whenever and wherever you see him; this demoralizes the savage, and although you may lose a few men in the rush, your loss will be less in the long run than if you endeavored to turn him out of his position by a heavy fire. As the result of all actions in a dense forest depends upon the company officers and on their fertility of resource, they must to a very great extent rely upon themselves and act upon their own responsibility."

ARTILLERY.

The drill and instruction of artillery, like that of infantry, may be divided into two parts, the manœuvre drill and the battle exercises. The first part is sufficiently dealt with by the present drill book. The instruction in sighting and pointing is fairly good, being covered by great gun practice, although there is little regarding the matter in the exercise manual; what is known by the officers of the service is passed along orally and the instruction is not as thorough as it might otherwise be. Before considering the employment of artillery it will be necessary to say a few words about the nature of the ammunition. The three kinds of projectile which may be carried are shell, shrapnel, and case, and earlier in this paper the 47-mm. gun was selected (for manual drag) as being able to fire shrapnel of effective size.

The percussion shell is the most useful projectile for general service. It is always used for ascertaining the range, as the puff of

* Mayne's Infantry Fire Tactics.

smoke from the explosion of the projectile shows the exact striking point. It may also be used against earthworks, entrenchments, and buildings, and its effect is good against masses of men and artillery; against troops in extended order its effect is moral rather than actual.

Shrapnel shell is effective only against men and horses, and when well delivered is very valuable; but it is difficult to regulate its point of bursting, on which all its efficiency depends. The shrapnel fuze should be a double acting one (time and percussion), as is the French service fuze. The proportion of shell to shrapnel varies from 3 to 1, to 1 to 3 in different foreign armies, but the average proportion is about 3 shell to 2 shrapnel. Case shot is used only at the shortest ranges, and the proportion carried is small; not more than 9 per cent.

Preliminaries to Opening Fire.—It is proper for the commanding officer of a battery to precede it on the ground it is about to occupy, in order to reconnoitre and decide upon the best position, and to observe the enemy, estimate his range, and note the arrangements made by adjacent forces. The commanding officer leaves his second in command to bring up the battery, and on its arrival the chiefs of pieces make their preparations for opening fire, while the battery commander assembles the officers and indicates the target, the exact point of it which is to be aimed at for the adjustment of the range, and also the point of aim for each gun after the fire is spread.

Range Finding.—The battery takes up a position for firing and loads with percussion shell. The range finding is by trial by the whole battery and is in two parts. In the first part, called the "trial firing" or "adjustment," it is the object to place the sheaf of projectiles so that it touches the target; in the second part, called "battery firing" or "rectification," it is the endeavor to cause the centre of the sheaf of projectiles to fall on the centre of the target.

To adjust the fire the battery commander points out the target and orders the projectile, elevation, and allowance for drift and wind, and the first piece fires. The explosion indicates whether the projectile falls short or over, and the elevation is altered sufficiently to make it almost certain that the second shot will fall on the opposite side of the target from the first. With this object the correction should be 400 yards for a range of 2000 yards or more, 200 yards between 1000 and 2000 yards, and 100 yards for less than 1000 yards. If there is the slightest doubt about the correct observation of a shot it must be rejected, and the next shot must be fired without altering the range. As soon as the target has been enclosed in a "fork"

(formed by two shots falling on opposite sides of the target), the next shot is fired with the range corresponding to the mean range of the fork, and a new fork is formed with this shot and one of the shots of the last fork. In this way the fork is diminished until it is only fifty yards deep, when the adjustment of fire may be considered complete, because fifty yards is within the limits of the natural dispersion of the shots, and the range for the entire battery is set at the smaller of the ranges composing the last fork. This method of adjustment is that used by the majority of European nations and differs somewhat from the English method, of which that described in the U. S. N. Ordnance Instructions (paragraphs 779–786) is an adaptation for use at sea.

Rectification of Fire.—The adjustment being complete, a series of six or eight shots is then fired with the range so found, and the result shows whether the elevation should be altered by 25 yards or not. The rules for altering the fire after the fire has been adjusted depend upon the theory of probabilities and the mean dispersion or deviation proper to the guns. If the centre of the sheaf of projectiles is placed exactly upon the centre of the target, a certain proportion of shot will strike the target, and half the remainder will go over and half will fall short; but out of all the shots fired, those which fall short are the ones which can be most accurately observed, and the rectification to be made is therefore based upon the proportion of shots which fall short. When the centre of the sheaf is adjusted to the centre of the target, this proportion varies from $\frac{1}{20}$ to $\frac{2}{3}$ according to the range and height of target, but the service rule for the Germans is to consider the rectification complete when from $\frac{1}{4}$ to $\frac{1}{2}$ the shot fall short. If, however, at 2000 yards range all of the first six shots out of the series of eight fall short, a correction may then be made to the elevation without completing the series; and if at 1500 yards range the first three shots all fall short, there is a very strong probability that the range should be increased. In general, the greater the depth of the target, the greater is the permissible proportion of shots "not short." The errors in direction are corrected by each piece separately, because the relative height of the wheels on which the lateral deviation greatly depends is different for each piece on account of the ground. In the case of a strong wind, the commander of the battery may make the first allowances and corrections for lateral deviation. After the rectification is complete, if the chief of a division (of two guns) observes one of his pieces steadily shooting "short" or "not short," he may make corrections of 25 yards to the range.

When the rectification is complete it is very frequent to spread the fire, that is, to cause each piece to fire at that part of the target which is most nearly opposite it, instead of continuing to fire at the centre or most prominent part of the target upon which the fire was first regulated.

Shrapnel Fire against Fixed Targets.—As shrapnel fire is more difficult to observe correctly than shell fire, it is usual to adjust the fire with shell and then change to shrapnel. By omitting to cut the time upon a double action fuze it explodes by percussion, and a shrapnel with this fuze may therefore be used to find the range. The effective use of shrapnel depends principally upon a low burst in front of the target. Having found the range by shell fire and begun shrapnel fire with the fuze adjusted to the corresponding time-length, the burst will probably occur either too high or too low, the proper height being three or four yards. There are two ways of correcting this error, either by altering the time-length of the fuze or by altering the elevation. The first method is better theoretically, but in practice the projectiles already cut and in the guns are wasted, so a practical rule is to alter the range. The distance between the point of burst and the target is then unchanged. If, however, it is seen that the explosions take place in rear of the target, then the time-length of the fuze and the range must both be decreased. When the commander of the battery thinks he has found the range accurately he orders the length of the fuze, and chiefs of sections may afterwards make alterations in the elevation of their pieces to rectify the height of burst, but they must not alter the fuze time-length.

Fire at a Moving Target.—In firing on an advancing target it is usual to enclose the target in a fork whose depth is proportional to the speed of the target's advance, and then to fire slowly at the less range of the fork until a shot is observed "not short," when the pieces that are ready fire rapidly, and then a new fork is formed and the same process is repeated. On account of the great depth over which a shrapnel shell is efficacious, its use is preferable against a moving target. To pass from shell to shrapnel fire, having fired shell slowly as above described until the target has entered the zone of natural dispersion of the shot, which will be shown by a shot falling "not short," the remaining pieces ready are rapidly discharged, and the fire is changed to shrapnel and continued with a range and corresponding fuze time-length, 100 to 300 yards less, according to the target's speed of advance, until a new fork is necessary.

In firing against a retiring target the converse of the above rules holds good.

The rules for firing against a target moving to the flank are similar to those for fire at sea against a passing enemy.

In firing at a target moving obliquely it will be advisable, if possible, to adjust the fire upon a point by which the target must pass, and fire rapidly when the target approaches it.

Observation of Fire.—Quick and correct adjustment of the fire requires the greatest care in the observation of each shot, for an error in observing a single shot may cause the waste of a large number of others before the mistake is discovered. It is therefore necessary to neglect doubtful observations altogether, and to adjust the fire only by good observations. To obviate false observations as far as possible, the following precautions are necessary:

The commander of the battery, whose duty it is to observe and correct the ranges, should choose a position well to the windward flank of the battery, but near enough to make his orders heard; and his observations should be assisted by a trustworthy man on the flank and advanced as far as possible, who should signal the result of each shot "short," or "not short," or "doubtful." When the fire is not spread, the point in the target most favorable for observation should be selected for aiming. Field glasses for the battery commander are better than the naked eye or than a telescope. Care must be taken to observe the cloud of smoke at the instant of the explosion, or it may drift and cause a false observation. Owing to the parallax due to the position of the commander of the battery, it will frequently be necessary for him to inquire from the chiefs of sections regarding the direction of the shot before he can decide whether it is short or not. When the target is covered, as sometimes happens, by little thickets or clumps of trees, observation becomes difficult, and an observer far out on the flank to signal the general result of groups of shots would be very useful. Finally, no opportunity should be lost of practicing the observation of shooting.

Fire Discipline and the Direction of Fire.—The position for the commander of the battery is on its flank; the more distant he is the more accurately he can observe results, but he must remain within reach of his voice. The target should be clearly pointed out to all. As for the order and rapidity of fire, the following rules should be observed: First, the fire should begin at one flank, usually the leeward one—this order should be maintained during rapid fire, and

should be neglected only where firing case shot; second, the rapidity of fire depends on the facilities for observation and the circumstances of the fight. Fire is usually distinguished as slow, ordinary, and rapid. Slow fire is used when the ammunition supply is low, when the phase of the action is a delaying one, when the "fork" has been determined for a moving target, and when observation is difficult. As the commander of the battery gives the order for firing each shot in slow fire, it may be used during the determination of the range. Ordinary fire, as its name indicates, is most generally used; the interval between shots is from 15 to 20 seconds in 6-gun batteries, and from 22 to 30 seconds in 4-gun batteries. Rapid fire is most frequently used in firing on a moving target after the latter has been seen to enter the beaten zone. The interval between shots should be from 6 to 8 seconds in a 6-gun battery. Rapid fire affects the aim, the smoke becomes annoying, and the physical effort is great, so that it cannot be long maintained.

A salvo or broadside is sometimes used to facilitate the observation of the range, and as the object is to increase the cloud of smoke caused by the burst, the guns must be fired exactly together. The limit of range for field artillery is that at which good sight aided by field glasses can observe the effect of the shooting. This is about 3000 yards.

Role of Artillery in Battle.—The role of artillery in attack is the preparation and support of the infantry advance. In the first stage of the fight the artillery opens fire at long range, say from 2500 to 1600 yards, and endeavors to silence the enemy's artillery and shake his infantry. This part of the action is usually an artillery duel. When the commander-in-chief considers that the time has come to push forward the infantry, the artillery is also advanced, the better to aid the infantry, and covers the latter by its fire as far as possible.

The artillery forms the stable element in the attack; its moral effect is very great, both upon friend and enemy, and it lends a solidity to the line which is lacking to the open order of infantry. Although artillery should always be well to the front, yet it is useless and specially vulnerable while in motion, so changes in position should be few and for considerable distances, for small changes in range do not much affect the power of artillery. When the infantry is closely engaged with the enemy, the artillery will be directed upon the reserves of the enemy in order to shake them, as well as to avoid injuring the attacking force. As soon as a position is taken the artillery will advance

and occupy it, to assist in holding it against a counter-assault. In the case of a repulse of the assaulting line, it will be the duty of the artillery to cover its retreat and prevent the enemy's advance.

On the defensive the action is begun by the artillery, which, if possible, should temporarily place part of its force beyond the main fighting line in order to cause the enemy to deploy early, for this renders the enemy's advance slow, and makes it more difficult for him to rectify any mistakes he may discover than if he were in closed formation. As soon as the infantry gets well within range, fire should be directed against it until the action is decided. The general rule for directing artillery fire both on the attack and defense is, that that arm of the enemy which is at the instant taking the most prominent part in the fight should be the principal target.

Employment of Machine Guns.—Machine guns partake of the nature both of artillery and small arms, and their management will accordingly be a combination of artillery and infantry methods.

In the attack, the machine guns will be advanced on the flanks or to some commanding position, where they will replace with great advantage the long range infantry fire which is so wasteful of ammunition, for the gun can keep up a more steady fire than the infantry; its ammunition supply is abundant, and its accuracy is much superior. The machine guns will, if possible, take their range from the artillery.

On the defense the machine guns will probably be more scattered than in attack, occupying the salient angles where infantry fire is weak; but as in attack, their fire will replace long range infantry fire. In this employment of machine gun fire it resembles that of artillery fire, but in the actual delivery of fire machine guns will follow the infantry methods, firing a few rounds rapidly and then waiting for the smoke to clear and to pass orders. The methods of range finding, too, will only be those practicable for infantry, and the use of two sights will happen as with the infantry. In general, the machine guns should manœuvre as artillery and fire as infantry.

Escorts.—Guns are usually able to protect their own immediate front, still they frequently require escorts; as the manual transport of naval field artillery necessitates large crews, these, if organized as suggested in this article, afford ample escort for protecting the flanks of their guns. When the guns are perfectly secure, this arrangement also permits the assignment of the relief platoon of one gun to act as another gun's crew and the withdrawal of a complete company to act as infantry.

Choice of Position.—In the choice of position, the first consideration is a clear field of view not only towards the target, but in every direction, and at close as well as long ranges. The cover afforded to the battery may afterwards be thought of, but the rule is general for artillery as well as for infantry, that cover must be sacrificed to an efficient fire.

The best locations for artillery are generally found just behind the crest of a hill, or behind a fold in a ground sloping gently towards the enemy, or behind hedges, thickets or cultivated fields, because these make it difficult for the enemy to observe the effect of his fire.

A damp and marshy soil just in front of and on the flank of the battery will diminish the effect of the enemy's projectiles, but in taking advantage of such ground care must be taken not to impede one's own future movements. Positions behind stone walls or on stony ground will cause dangerous splinters, and positions affording near cover for the enemy should be avoided. A hard, firm soil for the pieces to stand on is very important.

ENTRENCHMENTS AND SHELTER.

The effect of improved weapons is so great that it is absolutely necessary to provide some shelter against them, and for this reason troops should always carry their entrenching tools with them. The object of the defense is not to oppose an obstacle to the enemy's advance, and therefore both shelter trenches and gun-epaulements need be very shallow, because only cover is needed. With savage enemies, however, where forces are exposed to the sudden attack of great numbers, obstacles to hold them in check under fire are a necessary part of the defense, and wagons and baggage should be placed to afford such protection.

When in battle, every advantage should be taken of such natural shelter as can be found, provided the vigor of the attack is not too much sacrificed. On this subject Colonel Shaw remarks as follows, in his work on *Elements of Modern Tactics*, p. 182:

" A soldier posted behind cover to await the attack of an approaching enemy should not open fire until the adversary comes well within effective range. He should take advantage of the latter becoming necessarily exposed in advancing from one point of shelter to another, in order to fire at him with the best chance of success. But a soldier behind cover cannot reap the full advantage of his position unless he carefully follows all the movements of his approaching enemy ; never,

if possible, losing sight of him. He must therefore clearly understand that although he may conceal and protect himself by accidents of ground, the cover so obtained is only to be used as a means to an end, to enable him by its assistance the better to fight and overcome his adversary. This object cannot be attained by mere avoidance of the enemy's fire, and the soldier will never gain a victory by simply lying behind an obstacle. A habit of clinging to safe places would be worse for an army than any extent of rashness at all likely to be shown. Hence the soldier should be carefully instructed not only in the practice of using cover, but also of readily issuing from it at the proper moment. The most secure shelter must be changed without hesitation to right, left, front or rear, or abandoned altogether, in order to obtain some new advantage of position, or to follow the enemy's motions as he seeks to gain new shelter."

The general tendency of attack formations as developed at the great manœuvres of recent years has been to push boldly towards the enemy without much thought of shelter, and accept the necessary losses in the hope of quickly deciding the battle.

OUTPOSTS.

The duties of outposts are threefold, and are (1) to delay the enemy from attacking the main body of a force at rest sufficiently long to enable it to form up for action on its chosen ground. (2) To obtain information as to the numbers and disposition of the enemy so far as can be done without patrolling or reconnoitering to a long distance. (3) To prevent the enemy from obtaining like information with regard to one's own forces. From the official reports of the various landing drills and of the Panama expedition, guard duty in our Navy seems to have partaken principally of the nature of police duty, and the attention of sentries seems to have been directed towards the interior of the lines and the maintenance of order there rather than towards the enemy.

The line of sentries with its pickets and grand guard fulfills the first object of outposts by resistance to the advancing enemy until sufficient time has been afforded to the main body to prepare for action. This is a most important duty, and the necessity for occasional self-sacrifice in order to fulfill it is noted in the regulations of some services.

The distance at which the outposts are stationed from the main body of course depends upon the size of the total force. The line

of outposts also performs the duty of lookouts, and in this way also it may give timely warning to the main body.

To obtain information regarding the enemy's movements, patrols are employed. These are groups of men sent out to examine the country beyond the sentry line. They should not go farther than a mile, and should observe all secrecy in their movements.

The knowledge of patrol duties required of German troops is indicated as follows in Major Von Arnim's *Infantry Captain's Journal:* 1. Skillful and prudent conduct of detached men and patrols in examining a certain extent of ground; in seeking for and observing an adversary; in retiring before an enemy; in transmitting intelligence. 2. Proper instruction in the duties of sentries, and knowledge of how to act and how to transmit intelligence according to the different events that may occur.

Unfortunately, it seems to be assumed by our officers that instruction in such duties is unnecessary; but as these duties must be performed in war, it would be advantageous to pay more attention to them.

DISEMBARKING AND EMBARKING.

As soon as the boats of the landing forces are manned, they should be formed into divisions of some twelve or fourteen boats each, corresponding to the battalions and batteries of the brigade, and each boat should bear its distinguishing number both on bows and stern, besides a special mark for artillery boats. The latter mark would facilitate re-embarkation. Besides the ordinary equipment required for boats by the Ordnance Instructions, each boat should have a reserve of ammunition so that the brigade may land carrying its full supply, and that on re-embarkation the expenditures may be made good; the reserve ammunition may even be pushed to the front to meet the returning force.

If there should be boats armed with guns which it is not intended to land, they should be formed into a separate division immediately under the officer commanding the covering gunboats. Certain boats in the rear should be detailed to assist disabled boats, so as to prevent too much disorder among the leading boats. The brigade should be towed to the landing place, and should remain out of range while the artillery of the covering ships and steam launches and torpedo boats prepares the landing. Frequently, however, the artillery of the small boats will be of little assistance in preparing the landing, owing to its small height above the water and consequent lack of command.

When the artillery afloat has silenced the enemy, the landing may be attempted. There will be two typical cases in landing; in the first, the covering vessels will be able to maintain their fire until the landing is complete, either by virtue of a favorable flanking position or because the enemy's line of defense is some distance in rear of the beach, so that the covering gunboats may maintain their fire over the boats of the brigade. In the second case the enemy will be so placed as to oblige the fire from the gunboats to cease when the brigade moves to the attack, and thus he will be able to renew his opposition.

The first case is practically that of an unopposed landing. Each division of boats would pull for the shore, select its landing place, and after landing, the battalion would form and await orders.

In the second case the landing would be hurried and the force would be obliged to move to the attack immediately, so that the plan of attack should be carefully prepared and understood by all leaders before attempting the landing.

In landing, it will be the object to disembark the force in a compact formation from which the battle formation may be readily assumed. As the battalions will land abreast of each other, it will be convenient to form the corresponding boat divisions abreast of each other. The interval between the divisions should be 50 fathoms, which is about the battalion front and will allow 20 feet between boats with an interval of 40 feet between divisions. After landing, each battalion will form its own fighting line, reinforcement and support, unless it is to form the reserve; the formation of the different boat divisions should therefore be such as to permit the boats to land in succession. The following plan is suggested: The boats containing the skirmish line should lead in abreast of each other. Their distance apart should be at least 50 feet when first coming within range, in order that both may not be within the same sheaf of fire. The next boats containing the second line, or "reinforcement," should follow at a distance of about 150 or 200 yards, and should be slightly on the quarter of the leading boats in order to deprive the enemy of the chance of a raking fire. If the water is smooth, ricochets will be very effective, so that if other circumstances permit, the echelon should be formed on one bow-and-quarter line or the other, according to the direction of the twist of the enemy's rifling, which should have been made known by the Navy Department to the force engaged. The rest of the boats containing the third line, or "support," and the auxiliaries should

follow in double column at a distance of about 150 to 200 yards and should also be a little on the quarter of the boats ahead. In landing, the boats should be about 20 feet apart, but if boats containing the second line are intermingled with those of the first, it is a matter of no importance, provided that the first line on shore has moved forward so that no confusion occurs among the men. The artillery division of boats should be in the centre, for there the artillery can be better covered by the infantry, and it should be formed similarly to the other divisions. The two leading boats should contain half companies without guns and should be immediately followed by the corresponding half companies with guns. The rest of the battery should then be landed as rapidly as possible, the relief half companies preceding their guns in every case. The guns should be landed as early as possible because they lend great moral support, besides their actual service making it worth while to run the risk of their capture.

Beach Forces.—After the landing is complete it will be the duty of the beach-master and his force to take charge of the boats, to repair damages to them, to haul them off to an anchorage or draw them up in order on the beach, as the circumstances may demand, in order that the returning force may find no difficulty in re-embarking. If he expects an attack, either while the brigade is away or when it re-embarks, he should throw up entrenchments so as to aid the re-embarkation, taking care that they shall be planned so as to receive all possible aid from the covering gunboats. It will also be his duty to have ammunition ready to distribute to the returning troops, and to disembark and send forward all supplies needed for them.

In re-embarking, the flank companies should shove off first and the centre companies last. As in the haste and confusion of a re-embarkation under fire there will be many stragglers and men separated from their commands, each boat officer should observe before shoving off that his boat contains about her proper number, in order that on the one hand the last boats may not be overcrowded, and on the other that they may have crews sufficiently large and no boats be left. The guns should be kept on shore as long as possible. The Gatlings should be re-embarked first, as they are better able to cover the field guns from the water than are the field guns to cover them. The boats containing guns should push off before those containing the corresponding relief half companies, which should be left to cover the embarkation of the guns and then follow.

Boats which have shoved off should remain near the beach until

all are clear of the beach, when they should retire in succession, leaving a few as a rear guard to cover the departure of the rest and then to follow in their turn.

RIOTING.

It was the experience in the riots of 1877 that the respect paid to the United States forces was such that they never had to resort to fire; nevertheless it would not be well to rely too implicitly on that precedent.

In the first place it should be an invariable rule for United States forces never to appear before compulsory measures are a necessity. The mere parade of numbers is specially to be avoided, for it always arouses the mob; but the commander of the force should see that information regarding its presence is informally spread among the rioters. The commanding officer should obtain maps of the city and distribute them among his force, which should be quartered in some central building outside of the district occupied by the mob, and in communication with the local authorities. Wagons should be provided to convey the force at an instant's notice wherever its presence may be needed. Patrol or express wagons would be suitable.

The force should dismount from the wagons away from the scene of disturbance, form and march instantly upon the mob. In all probability the mob will yield, no matter what resistance it may have offered to the State National Guards; it should therefore be understood by every one in the force that fire is the last resort, to be employed only upon a direct order.

When in presence of the rioters, the sailors should form line with fixed bayonets and unloaded muskets at "arms port," and should move forward steadily without any halt. The commanding officer should be immediately in rear of the front line in order to feel the temper of the mob, and should be accompanied by three or four good marksmen of approved coolness whose rifles should be loaded. If fire should become necessary, a few leaders picked off by them under the immediate directions of the commanding officer might break up the assembly.

A small force may readily hold back a mob, but a much larger one is necessary to drive it, for the houses on each side of the streets must be searched, which takes time, and a small advancing force is quickly surrounded; and if blood has not already been shed, such a force loses that perfect coolness which alone can prevent it.

The troops may be formed either in a hollow square extending from house to house, or in closed column of divisions or of companies with a front reaching from house to house. At cross streets, when employing the latter formation, the leading company (or division) executes "platoons (or companies) right and left turn," and the cross street is thus closed in both directions until the column has passed, when the platoons (or companies) follow as the rear company (or division). A Gatling or shell gun would probably produce great moral effect upon the mob, and might be taken with the column, but it should not be used except in a desperate conflict, for when few shots at short ranges are required, they can be better applied from small arms than from machine guns.

Barricades should always be turned and the mob are not to be permitted to occupy squares and open places. The districts occupied by the rioters should have their water supply cut off, and it should be the object of the forces attacking the mob both to isolate and divide it.

CONCLUSIONS.

The conclusions to be drawn from a study of this subject are as follows:

The history of every nation shows that in almost every war the Navy is called upon to take a more or less active part against the best troops of the enemy, and therefore, while its knowledge of military matters need not be so profound nor so wide as that of the Army, yet it must have enough both of theory and practice to acquit itself without discredit. Naval officers should look upon duty ashore as an integral, though secondary, part of their profession, instead of adopting the idea given by the suggestions of the Ordnance Instructions that extemporary measures only are necessary for the creditable performance of military duties.

The artillery training is not sufficient, and that of the infantry is utterly insufficient and so far behind the times that it may be said to be on a wrong basis. The deployment of the skirmish line by numbers is a manœuvre condemned by the military nations of Europe, and we should hasten to adopt a development of the skirmish line by the group system, which best fulfills the requirements of battle.

When the Naval Brigade has been landed for exercise, attention seems to have been paid to manœuvre drill, but very little to scouting, reconnaissance, outpost duty, and the other minor operations of war which form the daily occupation of small forces in the field. Even

the target practice cannot have given results adequate to the expenditure of ammunition, for we learn from the Army Manual that some months of preliminary drills and exercises are necessary to enable a man to derive full benefit from range practice.

Finally, to those who fear to sacrifice the well known distinguishing characteristics of seamen in the endeavor to teach them soldiering, may be pointed out the seamanlike qualities and the military efficiency of the Naval Brigades in the long campaigns in the Indian mutiny, at the siege of Paris, and in Zululand. Attention may also be called to the facts that the large proportion of officers in the Naval Brigade decreases the necessary amount of detailed training for the men, and that the essential difference between soldiers and bluejackets lies not in the nature nor depth of their respective militant acquirements, but in the different modes of discipline and habits of thought developed by their daily life. Not only is it desirable to retain all the qualities of the ideal bluejacket, but it may be asserted that his versatility and resource give him the making of a better modern soldier than the soldier himself, who is trained to a certain rigidity of thought and discipline which is now in a large degree merely a survival from former necessities.

The splendid record of the marines, both in this country and England, bears out this assertion, for although the amount of their training cannot equal that of soldiers, yet their association with seamen, and consequent assimilation of naval modes of thought and action, more than supplies the deficiency.

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THE RESISTANCE OF AIR TO THE MOTION OF PROJECTILES.*

By Major James M. Pollard.†

A projectile in moving a given distance through the air displaces or thrusts aside a definite number of its particles, and an equal number of like particles are forced by the pressure of gravity into the space vacated by the projectile.

Let us assume

$$F = \frac{\text{Vel}^2 W}{2g}, \tag{1}$$

where Vel = velocity of displacement, W = the weight displaced in moving one foot, g (gravity) = 32.2 f. s., and F the resistance in foot pounds.

As friction may, with the smooth surfaces and limited dimensions of projectiles, be wholly neglected, a very slight addition to the values of the constant representing the form will be ample in any case save for rough turned or cast shot such as the old spherical shot; and for reasons that will appear as we proceed, friction will not for the present be considered in computing the resistance to elongated projectiles.

I shall use the symbol λ to designate all modifications of form, or resistance to the head.

I have computed values of λ for various forms of head used in modern artillery and small arms, and these values I have finally adopted as best for practical use.

* The committee to whom Major Pollard's paper was referred, finding it too long for publication in its original form in the Proceedings of the Institute, have taken the liberty of publishing only the portions which seemed to them of greatest value.

† Inspector of Rifle Practice, National Guard, District of Columbia.

We have, for the three forms of head—

$\lambda = .625$ for the flat head,
$\lambda = .375$ for the hemisphere,
$\lambda = .263$ for the ogival of $1\frac{1}{2}$ calibres.

Formula (1) may, for practical computations with the 8-inch projectile, be conveniently shortened as follows: The area displaced is 50 square inches, and with air of a density of 534.22 grains per cubic foot (Bashforth), equal to 13.1032 cubic feet of air to the pound, the 8-inch projectile will displace one pound of air in each 37.74 feet of flight, or one 37.74th of a pound, in moving one foot; and since dividing the Vel^2 by 37.74 is equivalent to multiplying it by the weight displaced in moving one foot, the operation can be further simplified by also dividing by $2g$ at the same time, or $37.74 \times 64.4 = 2430$.

Thus $$\frac{\text{Vel}^2}{2430} = F. \qquad (2)$$

Let Vel $= 825$ f. s. as Example 1. $F = \dfrac{680625}{2430} = 280$ pounds.

Of this the resistance would be,

$$\left.\begin{array}{lll} \text{For the flat head,} & 280 \times .625 = 175 & \text{pounds,} \\ \quad \text{" hemisphere,} & 280 \times .375 = 105 & \quad \text{"} \\ \quad \text{" ogival,} & 280 \times .263 = 73 & \quad \text{"} \end{array}\right\} \begin{array}{l}\text{as per tabular values} \\ \text{of } \lambda.\end{array}$$

It is next necessary to compute the energy expended in heating the air compressed at the head of the shot.

Boyle's law, formulated, is

$$P_1 V_1 = P' V', \qquad (3)$$

where $P =$ pressure and $V =$ volume; that is, the pressure multiplied by the volume is equal to the product $P' V'$ at any other pressure and volume so long as the temperature is constant.

When air is compressed adiabatically, that is, in a perfectly non-conducting cylinder, so that no heat is allowed to escape, and none is received from without, the temperature rises, and the pressure varies as the 1.41 power of the volume, and the product

$$P V^{1.41} \text{ is a constant quantity.} \qquad (4)$$

In the instantaneous compression and displacement of air at the front of a projectile there is no time for appreciable loss of heat, and the elevation in temperature augments the resistance precisely as it would in an air compressor. The volume is relatively greater, the mobility and velocity of flow or displacement are greater, and the

inertia of the air particles is overcome in less time. Each particle repels the others with greater energy, and the result is an increase in the pressure. As a question of impact solely, that is, the force of the blow of an air particle, the force is augmented because the particle is more quickly displaced. This is equivalent to a greater velocity.

The foregoing may all be briefly generalized as follows: A fluid or liquid mass or column, such as accumulates against the face of a displacing surface, cannot be made to transmit pressure in one direction only, and therefore cannot transmit the full force of impact to the plane. Air or gas cannot be compressed without the evolution of heat, and heat cannot be evolved without the expenditure of force.

Suppose air, having the initial pressure P, volume V, and temperature T, is compressed adiabatically, and attains the pressure P', volume V', and temperature T'; the relations of the pressure, volume, and temperature are as follows:

$$\frac{P'}{P} = \left(\frac{V}{V'}\right)^{1.41} \qquad (5)$$

$$\frac{T'}{T} = \left(\frac{V}{V'}\right)^{.41} \qquad (6)$$

$$\frac{T'}{T} = \left(\frac{P'}{P}\right)^{.29} \qquad (7)$$

This shows that the pressure varies inversely as the 1.41 power of the volume, and that the absolute temperature varies as the .29 power of the pressure, and inversely as the .41 power of the volume. For instance, when the pressure is doubled, or as 1 to 2, the volumes are inversely as 1 to 1.636, or directly as 1 to .611, and the absolute temperatures are as 1 to 1.222.

The following symbols are used in addition to those already explained:

A = area of shot in greatest cross section.
P = normal atmospheric pressure on such section.
$P' = P + F\lambda$.
V = normal volume of air at pressure P.
V' = volume of V at pressure P'.
h = height of a column of air of uniform density and weight, W, under normal atmospheric pressure.
T = the absolute temperature $= t + 461 = 62° + 461° = 523°$.
T' = the absolute temperature at pressure P'.

In the example already given, $F\lambda$ is, for the flat-headed projectile, 175 pounds, this being due to the air's inertia, or resistance to sudden displacement, and being computed by the velocity of displacement. This does not take into account the acceleration, or more rapid displacement due to the heat of compression.

Substituting the values in the above example,

$$\frac{P'}{P}=\frac{P+F\lambda}{P}=\frac{735+175}{735}=1.2381$$

atmospheres absolute pressure upon the head of the shot, if no heat had been evolved by the compression, that is, if T had remained constant. Here

$$\frac{P'}{P}=\frac{910 \text{ lbs.}}{735 \text{ lbs.}},\quad \frac{V}{V'}=\frac{1000}{807},$$

and the volume in inverse ratio, or $\frac{V}{V'}=1.2381$, or $=\frac{P'}{P}$.

Substituting the same values in formula (5): $\frac{P'}{P}=\left(\frac{V}{V'}\right)^{1.41}=$ as above to an inverse ratio of pressures as (1.2381 atmospheres)$^{1.41}$ or a direct ratio of (1.2381 volumes)$^{1.41}$. The pressures instead of varying inversely as the volumes, vary inversely as the 1.41 power of the volumes. This power of the volume must therefore be determined.

The logarithm of the ratio of volumes as above is .092766, and this is to be divided by 1.41, giving

$$\frac{092766}{1.41}=.06579$$

as the logarithm of the adiabatic inverse ratio of volumes. The corresponding number is 1.163, and the pressure, that is $F\lambda$, varies in this ratio.

Hence we have $175 \times 1.163=203.3$ pounds as the resistance to the flat head.

We can now compute the actual velocity of displacement. The ratio of the specific heats of air at constant pressure and constant volume is as 1.41 to 1, whether expressed in heat units or in foot pounds. The velocity of displacement due to that of the projectile is involved in the Vel^2 of formula 1; the velocity of displacement due to acceleration by heat, plus that due to the velocity of the projectile, is as the inverse ratio of the volumes, or, in the example just computed,

$$\frac{\text{Vel}^2\, 1.163\lambda}{2430}=203.3 \text{ lbs.};$$

consequently, since $\lambda = .625$,

$$\frac{\text{Vel}^2\ 1.163}{2430} = 326 \text{ lbs.},$$

whence the velocity of displacement = 890 f. s., though that of the projectile is but 825 f. s.

There is no resistance from vacuum at any velocity less than 945 f. s., and the above result includes all the resistance at 825 f. s. as computed by the first term of the formula for resistance.

The foregoing examples and methods determine the resistance or pressure upon the head of the projectile at any velocity. To this must now be added the minus pressure of the air, that is, the degree of vacuum at the base. This, as will appear, is susceptible of exact measurement.

So far as I am aware, all computations hitherto made as to the velocity of air into a void have omitted its elastic tension as an element in the calculation. The formula

$$\text{Vel} = 8.025\sqrt{h} \qquad (8)$$

would apply perfectly well to water or an inelastic fluid, but, as will be shown, is inapplicable to a gas. It has been argued from formula (8) that air could only rush into a vacuum with a velocity of about 1350 f. s., and that a projectile in motion with a velocity exceeding this must of necessity have a void at its base; but the 8″ ogival with its area of 50 square inches would meet a resistance from this cause alone of 735 pounds, whereas the total resistance at 1350 f. s. is but 520 pounds, which includes both the resistance encountered by the head as well as the augmented resistance upon the base due to the vacuum (see Bashforth's tables of resistances as determined by the chronograph). Clearly enough, therefore, the accepted theory is in this respect erroneous. By the formula already explained, the resistance to the head is 233 pounds, and this would leave 287 pounds only as the resistance to be charged to vacuum. As will be seen later, our computations will fix upon this as the correct resistance due to diminished pressure upon the base of the shot at this velocity.

Mr. Brownlee (experiments on safety valves) found that steam at 75 pounds pressure flowed into a perfect void with a velocity of 1446 f. s., instead of 2045 as it should by theory. Now from considerations which will presently appear I have deduced the following:

$$\text{Vel} = 8.025\sqrt{\frac{h}{2}} \qquad (9)$$

and this would make the Vel = 1452 f. s. Mr. Brownlee experimented

with various pressures and with results tabulated below, in columns 1 and 2.

Pressure in Boiler.	Obs. Vel.	Computed Vel. Formula 9.	Computed Vel. Formula 8.
100 pounds.	1459 f. s.	1468 f. s.	2080 f. s.
90	1454	1459	2063
75	1447	1452	2045
60	1437	1445	2030
50	1429	1432.5	2026
40	1419	1420.5	2006
30	1408	1405	1982

In all these experiments the observed velocity and weights and volumes of steam discharged in a given time were not affected by permitting the pressure in the condenser to equal half that of the boiler. That is to say, the quantity discharged in a minute into a practically perfect vacuum was not at all lessened or changed by allowing the steam to accumulate in the condenser until it equalled somewhat more than half that of the boiler pressure. It will, however, be noticed that formula (9) gives results substantially equivalent to those observed. This formula is based upon the following theories, and applies perfectly to all practical requirements.

1st. The velocity of an elastic fluid into a perfect void is wholly independent of the pressure. So long as the pressure and density bear, as by Boyle's law, the same relation to each other, the work to be done, that is, the inertia of the particles, and the force, that is, the pressure, bear a constant ratio to each other; the velocity therefore varies only with the temperature, as in the above table.

As to its velocity into a void, let us imagine a long or practically endless tube 8 inches in interior diameter, into which the air can enter without friction, and let it prior to such entrance be supposed perfectly void throughout its length. We can then admit the air, and speculate concerning the results.

As to these, the first will be that the force of gravity will project the air into the tube with a constant force of 735 pounds. This by formula (8) would give, Vel $=$ 1335 f. s., or a column of air 8 inches in diameter and 1 foot in length would be projected into the mouth of the tube in the 1335th of a second; and this would be the velocity of any fluid whatever under a like head or column of equal height, if each successive lineal foot of the fluid were to follow its predecessor in regular order unchanged in volume or density.

But here we have this column of air projected with uniform motion into the void, and with its particles at rest relatively to each other, that is, all in motion with equal velocity, and have the column confined on its sides by the walls of the tube, on its rear by the constant pressure of gravity, and upon its front portion no pressure or restraint whatever, in this direction it is absolutely free to yield, unresisted save by the inertia of its particles, which, as we know, constantly repel each other with a force we have defined as equal to the pressure of gravity, that is, equal to a force of 14.7 pounds per square inch. Under these conditions we must assume it to expand, to occupy a greater space, and to attempt to fill the void.

We have here the sudden liberation of a hitherto dormant force like that of a spring suddenly released. As a force it is exactly equal to the force of gravity, and it acts equally in both directions, forward, accelerating a portion of the column of air, and backward, retarding another portion. This last named action being in opposition to the constant pressure of gravity, since this column of air is already in motion with the force of gravity, and since it develops within itself a precisely equal force, sufficient, if entirely exerted in one direction, to bring it instantaneously to a state of rest, the exertion of this force for the 1335th part of a second is precisely equal to the force of gravity during that time. The velocity at constant density, or that due to atmospheric pressure, becomes that due to half the head, or $\frac{1335}{1.41} = 945$ f. s. In other words, the constant pressure, gravity, which equals 14.7 pounds per square inch, is resisted by the reaction of an equal and opposing force, and this force, because it is in motion instead of at rest, as opposed to gravity = 7.35 pounds per square inch.

In Mr. Brownlee's tables, deduced from experiment, we have:

Pressure in Boiler.	Pressure in Condenser.	Velocity of Efflux.	Weight of Steam discharged each Minute.
75 pounds.	70 pounds.	521 f. s.	35.9 pounds.
75	60	933	56.
75	50	1243	64.
75	40	1443	65.
75	30	1446	65.3
75	15	1446	65.3
75	0	1446	65.3

This shows that the velocity, when flowing into a perfect void, was somewhat less than that due to half the head, or h; that is, that the reaction of complete expansion $=37.5$ pounds per square inch plus the friction, resisted the flow, and that the velocity of an elastic fluid into a void is that due to half the head or pressure, and can never be exceeded.

The tube we have been considering is precisely what is found at the base of a projectile moving with great velocity. The projectile literally makes a hole in the air, into which the air rushes under the pressure of gravity; and, when the velocity due to this pressure is insufficient to overtake the projectile, it expands to fill the remaining space.

Now since the velocity at constant volume, that is, at atmospheric density, has been fixed at 945 f. s., the ratio of expansion becomes $\frac{\text{Vel}}{945}$. Thus, if the projectile be travelling at a rate of 1350 f. s., gravity forces in a second 945 feet of air into the space behind it, and this mass of air expands to fill the remaining space, or to a volume of 1.4285 as compared to unity.

The ratio of expansion holds for any fraction of a second and for any minute space, the 1350th of a second and a distance of one foot, or the 13,500th of a second and the tenth of a foot. We get in any case the same ratio of expansion. It is convenient to use the unit of one foot, because a single operation reduces the results to foot pounds of resistance. This expansion is also an adiabatic process. Adiabatic expansion is the reverse of adiabatic compression, and formulae (5), (6) and (7), by reversal of the symbols, are applicable thereto.

We have, then,

$$\frac{P}{P'}=\left(\frac{V'}{V}\right)^{1.41} \tag{10}$$

$$\frac{T}{T'}=\left(\frac{V'}{V}\right)^{.41} \tag{11}$$

$$\frac{T}{T'}=\left(\frac{P}{P'}\right)^{.29} \tag{12}$$

If the projectile in the above example has a velocity of 1650 f. s., the atmospheric pressure forces the air into the otherwise void space behind it with a velocity of 945 feet per second. Simultaneously with its projection into this space, the air, relieved of the pressure of gravity between its foremost particles and the base of the projectile, expands to fill the space. The ratio of expansion is as the velocities.

Now, $\frac{1650}{945}=1.7490$, that is, air of normal density expanded to 1.749 volumes. By this expansion the air bridges the distance between 945 f. s. due to atmospheric pressure, and the velocity of 1650 f. s. of the projectile, and by this expansion it performs work, and heat disappears. Hence the pressure is less than that due to the foregoing ratio of expansion; instead of varying inversely as the volume, the pressure varies inversely as the 1.41 power of the volume.

We find 401 pounds to be the resistance due to vacuum. The three forms of projectiles being alike as to their bases, we have as values for R when Vel $=1650$ f. s.,

$1125+401=1526$	pounds for the flat head,	
$579+401=980$	" "	hemisphere,
$372+401=773$	" "	ogival.

In Professor Bashforth's experiments with the projectiles, the resistance as determined by the chronograph was at 1650 f. s.,

1540	pounds for the flat head,	
985	" "	hemisphere,
775	" "	ogival.

When formulated the resistance is:

$$R=\frac{\lambda\pi q d^2 V^2}{8g}\left[1+\frac{\lambda q V^2}{2gp}\right]^{\frac{1}{1.41}}+\frac{\pi p d^2}{4}\left[1-\left(\frac{945}{V}\right)^{1.41}\right],$$

where—

$R=$ resistance of air in pounds to motion of shot.
$V=$ velocity of shot in feet per second.
$d=$ diameter of shot in inches.
$g=$ force of gravity $=32.191$ f. s. (Bashforth's value).
$p=$ normal atmospheric pressure $=14.7$ pounds per square inch.
$q=$ weight of a column of air one inch square and one foot long $=0.00052998$ pound (Bashforth's value).
$\lambda=$ a constant depending on form of shot.

If we put

$$A=\frac{\pi q}{8g},\ B=\frac{q}{2gp},\ C=\frac{\pi p}{4},$$

we shall have

$$\text{Log } A=4.81059,$$
$$B=3.74818,$$
$$C=1.06241,$$

and

$$R=\lambda A d^2 V^2[1+\lambda B V^2]^{\frac{1}{1.41}}+Cd^2\left[1-\left(\frac{945}{V}\right)^{1.41}\right].$$

The foregoing equation practically reproduces Prof. Bashforth's tables of resistance for all projectiles and all velocities up to 2000 f. s. as will be seen by reference to the tables of resistance in appendix. My theoretical values could be substituted for those computed from his tabular values of K, there being an absolute agreement throughout, but my work does not end with this mere reproduction of figures previously determined by experiment. It shows these figures to be deceptive, discloses defects in the guns and projectiles he used, and locates and defines these defects, thus suggesting improvement.

Consideration of Prof. Bashforth's and other experiments, and analysis of the chronographic records, while not essential to my theory, are therefore of the greatest possible interest as disclosing hitherto unsuspected complications. In fact, the problem as applied to practical use is not so simple as set forth in the foregoing, wherein, although excessive values of λ were used for purposes of comparison with actual experimental results, the reasons therefor were merely outlined, and the computations and formulae were used and explained as applied to a projectile moving with perfect steadiness, and perfectly aligned in the direction of flight; this in practical gunnery can be only approximated to, but, as will be shown, great improvements have been made over Prof. Bashforth's weapons, and equally great additional improvement is yet possible and practicable. Experiments with the chronograph recorded the resistance as it was encountered. The theories herein advanced show what the resistance should have been. Analysis of the experiments and chronographic records will demonstrate the correctness of the theory, and show that the resistance, while correctly recorded by the chronograph, was at the points measured largely due to unsteady motion caused by defective rotation, and that this excessive resistance is limited to the first portion of the range or flight, the experiments being over the portion of the flight covered by the screens, made under defective conditions. Satisfactory analysis of these experiments will be unavoidably lengthy and will require separate discussion. Before proceeding with this it will be proper to explain a characteristic departure from the theory so far advanced, which will be observed at velocities between 950 and 1075 f. s. It will be noticed by reference to the diagrams that the experimental curve drops, at 1000 to 1075 f. s., considerably below the theoretical curve. This is due to humidity, or the presence of aqueous vapor in the air. The above formulae will help explain this.

$T = 62° + 461° = 523°$ Fah. Now $\frac{T}{T'} = \left(\frac{V'}{V}\right)^{.41}$, and at 1000 f. s. $\frac{V'}{V}$ or $\frac{1000}{945} = 1.060445$ log .0258756, which multiplied by 0.41 = 1.0240045, and $\frac{523}{1.0240045} = 511°$ as the absolute temperature, or $511 - 461 = 50°$ Fah. as the temperature for dry air. But dry air is an unknown phenomenon in England. The vapor in condensing imparts heat to the air, as it does in air machinery where the pressure is indispensable, and so adds to the pressure upon the base of the projectile.

At 1050 f. s. the temperature of expansion falls to 39° Fah., and at 1100 f. s. to 28° Fah. This is below the freezing point, so that the air that is in contact with the base of the projectile is practically dry air as required by the formulas (5), (6), (7) and (10), (11), (12); and precisely at the freezing point, or about 1085 f. s., the two curves, theoretical and experimental, unite, as will be noticed by inspection of the diagram. This computation may be perfectly exact when the percentage of vapor in the air is known. It is sufficient for present purposes to indicate the cause of the very abrupt decrease in the resistance at velocities between 1085 f. s. and 1030 f. s.

A surprising difficulty here presents itself. The resistances at 2350 f. s. at the first screens are not those encountered at the last screens, but are 1825 pounds instead of 1350 pounds. Here are projectiles precisely alike in form, finish, and weight, moving with exactly equal velocities and apparently under precisely like conditions, yet meeting a difference of 475 pounds in the resistance of the air to their motion. These are not merely isolated cases, they are the averages of twenty-four rounds. So great an effect must have a cause that can be defined, and this cause must be some diversity in the conditions of the rounds at this velocity of 2350 f. s. Taking round 486 as the exemplar of its group, an analysis of its condition at 2350 f. s. compared with a like analysis of the condition of round 499 at this velocity will disclose the difference between them.

The Armstrong rifle had a twist of one turn in 35 calibres, equal to one turn in each 23.3 feet traversed. At the initial velocity of 2850 f. s. the rotation was therefore $\frac{2850}{23.3}$ or 122.3 turns per second. That this velocity is perceptibly reduced in the three-fourths of a second required to traverse 600 yards is most improbable. There is little

frictional resistance—almost none to the rotation of carefully made and smoothly polished shells.

The velocity of translation is, however, rapidly reduced, as shown by the diagram. The projectile must therefore perform a complete rotation while traversing less space, in fact each rotation is performed in less space than the preceding rotation. This is in effect a sharper twist, a rotation in a less number of calibres; at 2350 f. s. the projectile rotates once in each 19.5 feet traversed, which is equal to a twist of one turn in 29.3 calibres.

This therefore is at 2350 f. s. the rotation of the projectiles in the seven rounds comprising the group fired with the higher initial velocity, and the average resistance at 2350 f. s. of 1350 pounds. This rotation of one turn in 29.3 calibres may now be added as the remaining condition of round 486, and as the only condition wherein it can differ from round 499.

The latter, with an initial velocity of 2407 f. s., has a rotation of one turn in each 23.3 feet, or $\frac{2427}{23.3} = 104$ turns per second. At 2350 f. s. the rotation is one turn in each 22.8 feet traversed, equal to a twist of one turn in 34.2 calibres; this is the average of 12 rounds at this velocity.

Here then is the only difference in condition between rounds 486 and 499; in all respects, save velocity of rotation, they are alike. The one is rotating 120 times per second, the other 103 times per second. The respective powers to resist deflection are as the squares of these numbers, or roughly as 14 is to 10, and the respective resistances bear this inverse ratio to each other, that is as 10 is to 14. The one is at the last screens, 600 yards from the gun, the other at the first screens, 75 yards from the gun. The former, under the influence of rapid reduction in its velocity and relatively increasing twist or rotation to space traversed, has become steadied by 600 yards of flight. The latter, unsteady as shown at the first screens, also becomes steadied as its velocity is reduced. At the last screens its velocity is 2000 f. s., its resistance 1060 pounds, and here again it is the average of its group of 12 rounds. At 2000 f. s. it is rotating once in each 19.4 feet traversed, or one turn in 29.2 calibres. So far as rotation goes it is now equal to that of round 486 at the last screens, and the resistance, like that of round 486, is reduced or decreases throughout as the $(\text{Vel})^3$, again exactly confirming the cubic law of resistance.

And what has been shown with these rounds is true of all. Rounds 473, 461, and 470 show the same great initial resistance, the same rapid decrease in the resistance as the velocity is decreased, again decreasing as the $(\text{Vel})^3$, though somewhat more rapidly.

Each round obeys its own cubic law; that is, while being steadied and aligned, the lessened resistance due to a lower velocity, plus the lessened resistance attendant upon greater steadiness of flight, together constitute a decrease in the resistance, varying approximately as the cube of the velocity.

This, however, depends upon the velocity. With projectiles fired at 1300 or 1400 f. s. initial velocity, and encountering the rapid decrease that is met at the lower velocities, in addition to that due to greater steadiness of flight, the resistance might decrease as rapidly as the $(\text{Vel})^8$, and probably does so between velocities 1030 to 1080 f. s. when an additional cause is encountered. Now, to compare these results with my formula, with a view to further analysis, it will be seen that each of these rounds begins with a resistance approximately given by my formula making $\lambda = .33$, and that a line drawn from one of these initial resistances to the initial resistances of the other rounds will produce the curve marked λ .33. Also that most of the rounds or numbered lines terminate near the curve λ .20. The explanation is this: The projectile at the first screens was very unsteady. Had it continued uniformly so it would have continued to meet the same ratio of the resistance, and at lower velocities would have met the same resistance as projectiles fired with lower initial velocities. In other words, the uniformly unsteady projectile would have encountered at all velocities the highest or initial resistances, and this would have averaged about $\lambda = .32$ of my formula. Had Professor Bashforth used but three screens, close to the gun, this would have been the average, and would have been accepted as the resistance.

Suppose on the other hand but three screens had been used, and these had been the last three. The projectiles are, as has been shown, much steadier in flight at this distance from the gun, and the resistance recorded would have been $\lambda = .22$. The projectiles, starting under uniform conditions, are, after their 600 yard flight, uniformly unsteady. They have the same ratio of rotation to velocity, and if a projectile fired with an initial velocity of 2325 f. s., and with precisely the velocity of rotation that rounds 485 and 486 have at this velocity (see Diagram 3), was to continue the same ratio of rotation, or to continue uniformly unsteady, the resistance at all lower velocities would be

denoted by the curve λ .22. The proof of this is that precisely similar projectiles, having at the lower velocities the same relative rotation, are found at the instant they have this ratio of rotation to velocity to be crossing this curve λ .22, whatever the velocity of flight may be. As the initial resistance of all these rounds averages λ .33 of the formula, and as the terminal or last screen resistance averages about λ .20 of the formula, the resistance at the middle screens should be a mean between these extremes, or about λ .26. It is because of this that I added to the theoretical values of λ to make it correspond with experiment. Diagram 1 shows this to be the case. K is the resistance encountered at the middle screens at 350 yards from the gun; it is in fact a carefully averaged and interpolated series of resistances encountered through 600 yards of flight, and represents the average unsteadiness of the projectiles over this space; the high or initial or first screen resistances being averaged with the low or terminal or last screen resistances, the average being that of the middle screens. This average is reproduced by my formula making $\lambda = .26$. Above 2000 f. s. the two groups fired with such widely different initial velocities do not blend into a harmonious curve, and, as Professor Bashforth states, were not interpolated or modified, and the performance of the 8-inch gun with the excessive powder charges and 80-pound shell is markedly inferior to that of the 6-inch gun used at the lower velocities. To this is due the irregular curve K above 2000 f. s., and the fact that the average resistance above this velocity is greater than below it.

The resistance will now be understood as varying according to the distance of the screen from the gun. The resistance, whether taken at the first screens or the last, or as the carefully averaged values of K for the middle screens, proves the formula to be correct.

The question next in order is, what will the resistance be at 1000 yards from the gun? Manifestly these lines 485, 486, etc., cannot continue indefinitely or be prolonged entirely across the diagram, since that would terminate them at 1800 to 1200 f. s. with no resistance. They all point toward some lower value of λ, just as they all cross λ .24, .22, etc., and they cross these curves because these values of λ are too great, and because as they become steadied they approximate to their true theoretical resistance. When they become perfectly steadied they will touch but cannot cross the curve representing this theoretical resistance, in which $\lambda = 0.14$, due to the form of the projectile. The lines do not reach this curve simply because their

progress toward it was not recorded as it would have been by eight additional screens and 1000 yards of flight. But this is immaterial; the lines clearly show by their direction that this is their objective point, and that it is such can be demonstrated by our own experiments and those of Bashforth and Krupp.

A slight digression may be pardonable before further analysis of these experiments. The rotation of a projectile about its axis may be likened to a top, and its steadiness in flight may be supposed due to the same cause. A top when unskillfully thrown will, after some few unsteady gyrations, become steady or sleep, as children term it, and this seems to be true of the projectile: the cases are not, however, strictly analogous. A top only supports its weight against the action of gravity, and this action is proportional to the mass. The projectile sustains a pressure many times greater than its weight; thus with round 486 a shell weighing 80 pounds is sustaining a pressure of 2200 pounds. This is like a top having a rotating mass of 80 pounds carrying a non-rotating weight of 2120 pounds, a task which, judging by the diagram, it is unable to perform; but with the rapid reduction in velocity the disproportion between the rotating mass and dead weight is lessened, and at 625 yards from the gun the projectile, or top, carries its non-rotating load of 1300 pounds much more steadily than it did the 2200 pounds. It is in fact as though the top at each instant threw off a portion of its load. Considered from a strictly mathematical point of view the rotation of a projectile, like that of the top and gyroscope, is a very complex problem. In fact it is more complex than either, because it at the same time partakes of the characteristics of both; and I do not intend to follow this comparison beyond its practical bearing upon the flight of a projectile and the resistance it encounters. The rotation enables it, like the top, to resist deflection or rotation about its short axis, and, like the gyroscope, the "persistence of motion" tends to keep it aligned in the plane of its origin, or parallel to the bore of the gun.

The action of gravity forces the projectile into a curved path, and in consequence its point is soon elevated above its line of flight. This brings the upwardly curved lower surface of its point into more direct impact against the particles of the air than its lower parallel rear surface sustains, and tends to elevate the point or lift it. A portion of the weight of the shot is thus resting upon the point, as in the gyroscope, and the persistence of motion above mentioned elevates, or tends to elevate, the rear of the projectile above the line of flight.

This action, so far as it goes, is that of the gyroscope, and is accompanied by a true gyroscopic action, or retrograde movement of the base, which here represents the free end of the gyroscope. This movement is away from the direction of rotation, and it is this that by turning the base to the left or point to the right causes the phenomenon known as drift. I shall have occasion to recur to this again. At present it is designed to show that insufficient rotation to sustain the load or resistance must be followed by unsteadiness.

Returning to Diagram 3, I will now ask attention to the dotted continuations of the several lines representing the rounds after passing through the screens, and also before reaching them. At present, however, I wish to connect these lines with the theoretical curve due to form, or λ .14.

This may be done mechanically on the diagram by prolonging the lines till they intersect the theoretical curve for the particular form of head.* The velocity at this point, the rotation being still practically undiminished, will show the twist or ratio of rotation requisite to ensure steadiness. Or supposing the resistance to decrease as the $(\text{Vel})^3$, the resistance and velocity corresponding to λ .14 will determine when this point is reached without recourse to the diagram.

It may be concluded then that the resistance varies with the rotation. All Professor Bashforth's experiments prove this to be true. The diagram shows in lines 485, 486, 492, 499, 473, 461, and 470 the type of 95 per cent of all experiments with the ogival, and in rounds 495 and 472, the exceptions constituting the remaining 5 per cent. To sum this up it is shown that deficient rotation causes abnormal though tolerably uniform resistance; that this resistance quickly reduces the velocity of translation; that the angular velocity being undiminished assumes a greater relative ratio to that of translation, equivalent in fact to a quicker twist of rifling; and that this relatively greater angular velocity rapidly aligns and steadies the projectile, the resistance during this portion of the flight decreasing as the $(\text{Vel})^3$. The twist indicated by these experiments is for velocities of 2500 to 3000 f. s., 1 in 24 calibres; for 2000 to 2500 f. s., 1 in 26 calibres; and for 1700 to 2000 f. s., 1 in 27 calibres, as the minimum.

It thus appears that the twist given to modern rifles as the result of observation and experiment is a pretty close approximation to that actually required, though with our own 6″ and 8″ guns it is still too slow to give the best obtainable results. The unsteadiness with an

* The author here assumes $\lambda = .141$.

initial rotation of one turn in 30 calibres is, however, not so marked as with the Bashforth twist of one in 35, and is difficult to detect with any instrument less precise than the Bashforth chronograph. We can, however, show very clearly that it exists, using only the range records from the proving ground at Annapolis and the data from Krupp's bulletins.

The effect of the great initial resistance is, even with our 6″ rifles, to make the results of experiment with different angles of fire appear inconsistent with each other. Thus, judging by the angle required for a range of 3000 yards, the angle for 6000 yards is too low. The gun "carries" farther than it should, predicating the resistance as proportional to that at the shorter ranges. Or, reversing this, and arguing from the range observed at 10° or 12° elevation, the ranges at 2° to 5° are short of what would be expected. This must follow, because so great a proportion of the total resistance at even the greatest elevations is encountered is the first 1000 yards of the trajectory. Attempts to explain this discrepancy by the rarified atmosphere at the vertex of the trajectory are but partly satisfactory. Some argue that the remainder is due to the jump of the gun, but this is usually allowed for in laying the gun. No explanation is possible save that of initial unsteadiness.

In the strict theory of air resistance λ is constant for any given form of projectile and for all velocities. In practice, however, it must be varied to suit each particular case, and I do not at all pretend to have defined all modifying influences upon the resistance. Among other things the effect of weight or mass upon the initial unsteadiness is prominent; a heavy projectile will doubtless be more steady than a light one of like form. The data at command is insufficient for the formulation of specific rules for all cases, but such rules can be deduced in all probability from the records of Prof. Bashforth's forthcoming series of experiments.

To resume consideration of the diagrams and comparison of the projectile and top: It was stated that the top, after some unsteady movements, gradually steadied itself before going to sleep, and it may seem that the projectile, partly tumbled perhaps by the great pressure of the powder gases or by vibration of the gun, etc., became unsteady at the instant of firing from causes other than insufficient rotation. This is probably in part true. If the projectile have a faulty centre of gravity or balance, the enormous pressure upon its base just after leaving the muzzle will turn it about its short axis, and

in any case will greatly exaggerate any slight unsteadiness caused by the vibration or recoil of the gun or by balloting within the bore.

The projectiles, if perfectly aligned and steady upon leaving the muzzle, could not from deficient rotation alone become so instantaneously unsteady as to exhibit the maximum resistance within fifty yards of the gun. In fact they do not. Prof. Bashforth rejects the records of many of the rounds because they disclose the seeming paradox of a greater resistance at the second and third screens than at the first and second, in spite of the necessarily greater velocity at that point. In these cases the projectiles had not at the first screens acquired their maximum unsteadiness. Round 495 is an instance in point, and it is these exceptions that prove the rule. Passing the first screens with a resistance represented by λ .24, less by far than that of any other round in Prof. Bashforth's entire series of experiments, it remained while passing through all the screens uniformly unsteady, and its resistance at velocities 2400 to 2150 f. s. is given by my formula with λ .24. At the last screen this round encounters a much greater resistance than any of the others in the entire series of experiments. Starting under more favorable conditions than any of its fellows, because it in some manner escaped the initial unsteady impulse, it could not retain this advantage; it met less resistance; its velocity was not so quickly reduced, and therefore it had less relative rotation, and because of this it must necessarily traverse a greater space in order to suffer the retardation or reduction in velocity requisite to affect the ratio of rotation. At equal ratios of velocity to rotation the resistance equals that of the others. Retardation, less at the beginning, was inevitably greater at the last screens, because the resistance due to insufficient rotation is a penalty that must be exacted; and this resistance is a constant quantity, though some of the rounds encounter it in much less space and time than others.

It has long been observed that an increase in both range and accuracy accompanied increased rapidity of twist. In small bores especially has this been noted, and this has seemed in some respects inexplicable. Why, for instance, a rifle of .45 calibre, with a given powder charge and projectile with which it made excellent target practice, should be excelled by a like rifle with the same powder charge and projectile, the only difference being a more rapid twist of rifling in the latter. The explanation is found in the foregoing, and no other is possible. The first rifle had an insufficient twist of rifling, as also, probably, had the second, though in less degree, so that the

second wasted less of its energy in useless air resistance. As before stated the twist must be more rapid with high-powered guns, and must be proportional to the resistance; the hemispherical-headed projectile requires a more rapid twist than the ogival, and less than the flat head. At initial velocities not greatly exceeding 1000 f. s. a very slow twist suffices, because, if unsteady, the velocity is quickly reduced to 950 f. s., and below this the slight resistance does not demand rapid rotation.

We come as a necessary consequence to the proposition that the range with any gun and projectile is essentially limited and defined by the twist. A slow twist may give, with moderate powder charges and velocities, excellent results as to range and accuracy; but there is a limit not greatly exceeding these moderate velocities beyond which the charge cannot with advantage be increased, and this because the enhanced unsteadiness and resistance are so gréat as very quickly to reduce the velocity to that of the smaller charge. The increased energy of the projectile is thus quickly absorbed, without advantage to the range or penetration. This is the case with the Springfield rifle. The bullet, with its slow rotation, cannot be advantageously propelled with heavy charges, since greater velocity simply results in greater unsteadiness, in a very limited increase in the range represented by the short distance traversed in an unsteady condition while the velocity is being reduced to that obtained with the lower charge, and in impaired accuracy because of the greater vibration and recoil. With a quicker twist a greater powder charge results in very apparent flattening of the trajectory and improvement in range and accuracy, because the additional energy is not, as with the slow twist, wasted (in small arms) in the first hundred yards of flight.

Experiments with the service rifle have shown:

1st. That the charge of 500 grains lead and 70 grains powder gives best results, and that no possible increase in the powder charge increases the ultimate range to any useful extent.

2d. That with this charge of 70 grains powder and 500 grains of lead the range is substantially extended by increasing the twist from 22 inches to 18 inches.

3d. That with this latter twist a charge of 80 to 85 grains and 500 grain bullet results in a very decided increase in the range.

It is unnecessary to multiply illustrations. Analysis of Bashforth's experiments and others may be indefinitely extended beyond what has been attempted herein, and investigation of any well authenti-

cated and carefully observed experiment will confirm the conclusions I have reached. To any and all of these my formulas are applicable with exact results, when the effect of unsteadiness, for which the formulas make no provision, is ascertained and applied to modify the resistance and range.

Will this not also afford an indication of the penetrating power of projectiles at various distances from the gun? I am convinced that it will. If the unsteady or wobbling flight is a disadvantage in penetrating air, it is also, and to a greater degree, a disadvantage in penetrating a solid. Rapidity of rotation acts in three ways to increase the effective power: 1st, by holding the shot rigidly aligned point on to its work; 2d, by the energy stored up in its rotation; 3d, by lessening the resistance to be overcome between the gun and its target.

The disadvantage of a greater strain upon the gun is a serious and a very obvious objection to the quicker twist; but it is imaginary. With the quicker twist the powder charge may be reduced and a slower powder used. The strain upon the gun would be slightly lessened, and the initial velocity also, but yet the range, accuracy and penetration would be greater than before; this would be accomplished also with less recoil.

The enormous total of energy lost by unsteadiness is readily computed by the values of λ required to harmonize ranges at different elevations. To this must be added the excess of force required by the unsteady shot to pierce its target at an angle, which it always does. Possibly at extremely short ranges or within fifty yards the unsteady projectile and higher initial velocity would have an advantage, but even this is doubtful, because it must make a larger hole in the target, and, as before stated, penetrate it at an angle to the line of flight.

Professor Bashforth was somewhat discouraged during the course of his experiments with elongated projectiles, and at one time looked forward to a careful analysis of the experiments with spherical shot as likely to be free from some of the vexed questions arising with the rifled guns, and as "wholly free from unsteadiness," etc. The problem presented by an ordinary spherical shot, rough turned or cast, is simply incapable of exact solution. The first uncertain element would be termed surface friction, though this is a misnomer. It is not properly friction, such as friction of adhesion, of viscous bodies in contact, etc., but it is the impact of air particles against

countless minute projections, cavities or crystals, and which in the aggregate approximate more or less and to an indeterminate degree to impact against a plane or flat surface. Computations based upon the form are therefore neutralized because necessarily inexact.

Hutton experimented in this direction and with results that seem to have surprised him, but modern artillerists do not seem to have done so. A rough turned shot such as I have seen used would doubtless meet 50 per cent more resistance than if smoothly polished, and those used by Bashforth from 15 to 30 per cent more.

But even attempts at a careful analysis of this problem would require a previous discussion of results of various experiments in other directions. From one of these, the tube anemometer of M. Arson, we might possibly obtain some light on our problem, but the limits of this paper allow of no further amplification of our subject.

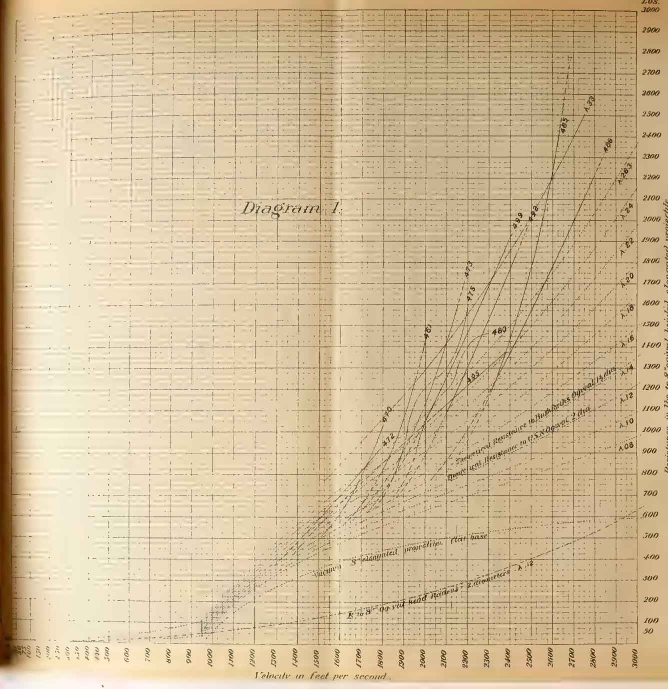

Diagram I.
Lbs.
Theoretical Resistance to U.S.N. Ogival 2 dia.
Vacuum
470
472
473
475
480
481
485
486
492
495
499
λ.08
λ.10
λ.12
λ.14
λ.16
λ.18
λ.20
λ.22
λ.24
λ.32
Velocity in feet per second.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES FROM THE JOURNAL OF LIEUTENANT T. A. M. CRAVEN, U. S. N.

U. S. S. Dale, Pacific Squadron, 1846–49.

I.

Tunis Augustus Macdonough Craven was born in Portsmouth, N. H., January 11, 1813. He was the youngest son of Tunis Craven, a Naval Storekeeper, stationed at the Portsmouth Yard, and of his wife, a daughter of Commodore Thomas Tingey, U. S. N. In his youth he attended the Columbia College Grammar School in New York, his father having removed his family to Brooklyn, when ordered to duty in the New York Yard. February 2, 1829, Craven was appointed an acting midshipman from New York (warranted November 18, 1831), and was attached to the Boston and St. Louis. Promoted to Passed Midshipman in September, 1835, he was on duty in connection with the Coast Survey almost continually until 1843, nearly two years after his promotion to Lieutenant, in September, 1841. In 1838 he married Miss Mary Carter, a member of one of the oldest and most influential families on Long Island, who died in 1843, leaving three children. The same year Lieutenant Craven was ordered to the receiving ship at New York, where he remained until ordered to the Dale in May, 1846. In the meantime he had married again and removed from Brooklyn to Bound Brook, N. J. His second wife was Miss Marie L. Stevenson, of Baltimore, Md., by whom he had three children. After his return from the Dale he was employed on Coast Survey duty, with the exception of a year (1850) at the Naval Observatory, till 1859. Most of this time he commanded the steamer Corwin, but in October, 1857, went in the Varina in command of the Atrato expedition, which was for the purpose of surveying a route for a proposed ship canal through the Isthmus of Darien via the Atrato and Turando rivers.

In 1859 Lieutenant Craven was ordered to the command of the steamer Mohawk, Home Squadron, in which he captured two slavers; in 1860 he saved

the crew of the Bella, a foundering Spanish vessel, for which he was given a gold medal and diploma by Queen Isabella II. About the same time the New York Board of Underwriters presented Mrs. Craven with a handsome silver service for efficient services rendered to merchant vessels at sea by her husband.

In 1861 Lieutenant Craven was ordered to command the Crusader, Home Squadron, but was shortly after promoted to Commander and ordered to command the Tuscarora, special service. The Tuscarora went to England with orders to report to the U. S. Minister, Mr. Adams. While in Southampton the Confederate steamer Nashville came in; but upon her leaving, the Tuscarora was unable to follow until the expiration of twenty-four hours, when, giving up the chase, Commander Craven went to the Mediterranean, where he succeeded in watching the Sumter so closely that her officers and crew finally deserted the ship at Gibraltar.

The Tuscarora was ordered home in 1863, and Commander Craven was detached and ordered to command the Tecumseh, then building at Secor's yard, Jersey City. In the following spring the Tecumseh left New York and joined the squadron of Admiral Lee in the James River. Shortly after the Tecumseh was sent to join Admiral Farragut's fleet in the projected attack on Mobile. The position of Commander Craven in the attack, which took place August 5th, was at the head of the column of monitors which was on the starboard hand of the wooden vessels between them and Fort Morgan. Admiral Farragut in his reports states: "The attacking fleet steamed steadily up the main ship channel, the Tecumseh firing the first shot at forty-seven minutes past six o'clock. At six minutes past seven the fort opened on us, and was replied to by a gun from the Brooklyn, and immediately after the action became general. It was soon apparent that there was some difficulty ahead. The Brooklyn, for some cause which I did not then clearly understand, but which has since been explained by Captain Alden in his report, arrested the advance of the whole fleet, while at the same time the guns of the fort were playing with great effect upon that vessel and the Hartford. A moment after I saw the Tecumseh, struck by a torpedo, disappear almost instantaneously beneath the waves, carrying with her her gallant commander and nearly all her crew." Thus perished, in his fiftieth year, one of the brightest and bravest officers in the naval service. The captain and the pilot were in the conning tower directly over the turret, whence there was no escape save through a narrow opening. Upon reaching this Commander Craven turned to the pilot and said, "You first, sir." The pilot, John Collins, escaped, and, as he related, the vessel sank under him, carrying her crew of one hundred and sixteen in all, save himself and the few that were able to escape through the port holes. A buoy in Mobile Bay marks the spot where the Tecumseh lies, the iron-bound tomb of the gallant Craven and his devoted crew.

The notes are presented to the Service for whose honor Commander Craven gave his life, through the kindness of his daughter, Mrs. Charles W. Thomae.

C. B.

June 6, 1846.—At daylight we sailed from New York for the Pacific Ocean. I was very glad to sail; it was too trying to lie almost within sight of my home and be unable to go to it. By breakfast time we had discharged our pilot, with our last letters of adieu; our native land was fast receding from our sight, it soon became as a faint blue cloud on the horizon and then disappeared. What are the charms of sea-life? Where is the exciting pleasure which causes "the exalting sense, the pulse's maddening play"? Such things exist only in the minds of poets who have made a pleasure trip on a mill-pond; for myself, I have never been able to discover the delights of the sea. True it is that on board of a man-of-war, where one comes down to the realities of old ocean, there is very little room for poetic feeling; and with us indeed there has been much want of comfort, added to the painful feeling that each day was widening the distance from our homes. Our first week out has been attended with most disagreeable weather, chilling head winds and rain; but now the prospect lightens somewhat and we are cheered with some rays of sunshine. But our ship is under water the whole time and I see small chance for comfort. I am quite alive, however, to the beauty, the magnificent grandeur of the ocean and its wonders. These things are well worth seeing, but where one devotes his life to "going down to the sea in ships" he is somewhat like the boy who, having just learned the alphabet, declared that it was "hardly worth while to go so far to learn so little." The sea is sublime, though. Whether in the frenzy of the storm or in gentle undulations of the calm — for it is never at rest — one cannot look out upon the deep without sensations of awe and wonder. My mid-watch the other night was closed amid one of the most glorious displays of Nature's charms I ever beheld. Never have I seen the day ushered in with such majestic beauty. A few fleecy clouds skirted the eastern horizon, the sky overhead was perfectly clear and most brilliantly studded with stars. Day had not yet dawned when I was startled by a sudden flash of light in the east which had the appearance of a fire; but in a few moments the gloriously beautiful planet Jupiter leaped forth in all his splendor, then followed the new moon with her golden horns, and then came Aldebaran as if to herald in the morn; for day, "beautiful day," now sent up its streams of faint light from the eastern skies, and before it the lesser lights of night retired. The two bright stars named, with the moon in company, rode triumphantly, and seemed to vie with each other in brilliant beauty.

Tuesday, June 23.—We have the trade winds now, having taken them in about latitude 28° N.—much too soon, for we have not yet got far enough to the eastward, and are consequently very uncomfortable, with our close-hauled ship striving against a heavy sea.

Sunday, June 28.—Divine service is held every Sunday by the captain, who reads the prayers in a solemn and impressive manner, but it is not like the service of those who meet on shore to praise their God. What a life this is! Such a pitching and rolling, tossing and reeling about we have had to undergo! For the past week our little ship has been struggling in contention with the seas, and has been about as uncomfortable as she can well be. Our prospects, however, are brighter to-day, for the wind becomes more favorable and we may yet make a fair passage.

Saturday, July 4.—Dismal weather; several days of incessant rain, with light and baffling winds. We make but little progress and are having a most uncomfortable time. To-day we made an attempt at celebrating the day with as much ceremony as circumstances would allow. Our dinner was julienne soup, fresh salmon, beefsteak pie, boiled ham, fresh lobster salad, with dessert of dried fruits and nuts, champagne and madeira wherewith to drink to absent friends.

Sunday, July 12.—Fine weather. For four or five days we had to contend with a fresh southwesterly wind, a most unusual circumstance, but it has at last veered round to the eastward of south, and we are now bounding along at a fine rate, with strong hope of making our port soon.

I have been reading "The Crescent and Cross." Warburton is a clever and sensible traveller. How I envy such men their talents and opportunities! Nothing can be more attractive in the romance of life than the faculty of making one's self at home whether among the courts of Europe or the Arabs of the desert. And the gift of language, being able to address ourselves to any one whom we meet—it gives the charm to our travels, to be able to learn so much of the character of the people among whom we may chance to be thrown, and is the greatest enjoyment within the wayfarer's reach. The picture of the Oriental steamer is too charming! What luxury they enjoy who go to sea in a fine English packet! Why, by steam, it is no more than a pleasure trip. But with us how changed the scene would appear! There is no comfort on board of a man-of-war.

Thursday, July 23.—In my watch last night I, at half-past ten, discovered the light on Cape Frio, and in an hour afterwards was

able through the darkness of the night to distinguish the bold promontory's dim outline. At daylight this morning we found ourselves close in with the headlands off the harbor of Rio de Janeiro, and fanning along with the very light winds, we entered the harbor and anchored in the afternoon.

What a delightful change it is to find one's self, after a tempestuous voyage, comfortably at anchor, where strange and new faces greet you on all sides, where old friends, former shipmates, are to be met, and where exercise on shore, fresh provisions and delicious fruits are to be had. None know these pleasures but those whose lot it is to pass their life in the ocean's trackless waste. A queer creature is the son of ocean; but, wedded to the sea as he may be, he is always happy when he gets into his port. The pleasures of the land, the comforts to be had on *terra firma*, are beyond the attractions of the foaming deep.

The harbor of Rio Janeiro is certainly one of the finest in the world. It is capacious enough for the accommodation of all the navies of the world; all may lie here at anchor in security, and there is sufficient depth for the largest vessel to enter at any time, day or night, without hazard. You seem to be at anchor in an extensive lake encircled with lofty mountains, whose broken sides, covered with perpetual verdure, give a beautifully picturesque appearance to the whole. The city of Rio is about two miles and a half from the sea, and lies at the foot of a range of high hills which rise abruptly in its rear. The style of building is similar to that of Lisbon, the houses being mostly of stone, either white-washed or stuccoed, two stories high, and occasionally three, covered with red tiles. The streets, like those of Lisbon, are narrow, and paved with blocks of granite, having side-walks scarce wide enough for two persons to pass; they are in general quite clean in the better portions of the town. This style of building, so peculiar to the towns of Spain and Portugal, is to my eye very agreeable; though not pretty nor ornamental, there is an appearance of such comfort and airiness about them as is adapted to the climate. The windows of the upper stories are all provided with graceful balconies, but without the jalousies so common in the south of Europe. On the whole I think it a fine city. The population is about 250,000. It is the largest and most flourishing town of South America, as it may well be, for it is situated directly in the great highway between India, the Pacific, and Europe and America, and it affords a most convenient port of refreshment to

vessels of every nation. The harbor is always filled with shipping, and the commercial advantages of the place are very great.

The varied productions of Brazil are such as to give her the resources of a great nation, and under a liberal and well conducted form of government this country must one day take a high stand in the scale of nations. But the empire must struggle before it finally shakes off the yoke of monarchy and the bigotry of the Romish Church, which, combined, prevent the rise of all. The government at present is that of a limited monarchy. The Emperor is a young man of about 21 years of age, vested with little authority beyond that possessed by the President of the United States. All laws are enacted by a legislative chamber, whose sanction is necessary for all public expenditures. The salary allowed the young Emperor is about $400,000, which is said to be insufficient for the maintenance of his kingly household, and he is obliged annually to draw upon his private estates to supply the deficiencies.

July 25.—A small party of us to-day took horses and made an excursion to the celebrated peak of the Corcovado. On leaving the city we followed for some miles the course of the aqueduct, a fine work constructed in 1740, which brings the supply of water to the city from a distance of about seven miles. Never in my life have I beheld such a magnificent country as was exhibited to my view. Our road was a circuitous one, gradually winding its way up toward the summit of the ridge. The pathway is narrow, in some places being only sufficient for one horse to pass, and sometimes so steep that the ascent was laborious to our animals, the descent perilous to any but horses accustomed to mountain roads. The way is sometimes through forests of the magnificent tropical trees, with shrubbery of every variety forming the undergrowth, and the great yellow jasmine climbing to the tops of the highest trees and filling the air with its delicious perfume, with the giant aloe and a numberless variety of lovely flowers of every hue in the hedgerows, all seeming to make one great and magnificent bouquet. Now we are going through a forest whose dense growth and lofty tops completely shut out the sunshine and give a chilling dampness to the air; now we come to a cleared space of more level ground, where the hand of civilization has reared a pretty country seat and planted groves of golden oranges; a coffee plantation is beneath us, and hedges of the delicate acacia with its yellow flowers form a barrier against intrusion. Now we emerge from the thicket, and from the mountain side have a mag-

nificent view of the most lovely country in the world; now our horses are on the brink of a precipice, where a false step would plunge us over the crags, hundreds of feet below, but they never miss their foothold, and we gallop on and soon have a fine glimpse of the beauteous bay, with its fleets at anchor and vessels coming and going. The sides of the ridge are everywhere encircled by lesser conduits, which convey the smallest and most insignificant rivulet to the main trunk of the aqueduct; not a drop of water is allowed to run to waste. We now reach a terrace on which is a large reservoir for feeding the aqueduct; and here too stands a pavilion, seemingly for the accommodation of pleasure parties, for there is a merry pic-nic party holding possession as we pass by; a miserable stable is near for the horses, and we give ours in charge of a half dozen noisy negroes, who seem delighted with the prospect of reaping a harvest of coppers. The remainder of the ascent is made on foot, and a toilsome walk we have, climbing up the steep sides of the hill, which becomes very abrupt as we approach the summit. The peak is finally reached, however, and a most gloriously beautiful prospect lies at our feet on all sides; ocean, mountains, valleys, the splendid bay, the town, the luxuriant tropical verdure which covers the hillsides, all are more grandly magnificent than I can describe.

We gazed on the beauteous scene, lost in admiration and wonder; at each turn finding some new object to attract our attention and excite our feelings of delightful surprise. The peak of Corcovado is about 2500 feet in height, its summit is of granite, and towards the east it appears so precipitous that one might leap to the valley below without breaking his fall; a light iron railing has been thrown around the summit for the safety of the pilgrims. We could not tire of looking on the scene around and beneath us, but the day was on the wane and our time was limited; hunger, too, admonished us that it was late, so at a "dog trot" we descended to the place where our horses were stabled, and mounting, started at a rapid pace down the mountain side. The boisterous negroes gave a tremendous shout as we left them, and we heard them for some time quarrelling about the "spoils" to be divided. We rode on as rapidly as the roughness of the road would permit; indeed, wherever it was practicable we raced, for we were in fine spirits, all highly exhilarated by the charming scenes through which we had passed. In good time we reached the town, and sat down to a delicious little dinner which our host of the Hotel d'Europe placed before us at 5 o'clock. We dined sumptuously, and

having rested sufficiently, sauntered about the streets of Rio by night. Some of the shops are quite stylish, and many of them when lighted up have a pretty appearance; there are no novelties displayed except the feather flowers, which are really beautiful. The largest establishment had extensive ranges, exhibiting every variety of flower imaginable; some of them, made from the wings of the beetle, are very rich and have a most brilliant appearance at night; the feather flowers are most delicate, and exceed in beauty and their close imitation of nature the best French flowers, and exceed them in price too.

The city of Rio de Janeiro has no fine buildings; there are a number of churches, convents and monasteries, but none of them are imposing structures. The palace is extensive, but in exterior quite plain. The Empress is daily expecting an addition to her royal responsibilities, and the guns of the batteries and shipping are loaded ready to announce the fact.

On Wednesday the 22d, about 8 o'clock in the evening, a brilliant and beautiful rocket shot up from the signal tower above the town; it was quickly followed by a splendid display of fire-works, and then pealed forth the thunder of artillery from every fort and ship in the harbor; the bells chimed merrily, and the bay was fairly illuminated by the discharge of the cannon. The accouchement had taken place, a young princess was born to this world of trouble.

At daylight on the following morning the Brazilian men-of-war again fired their *feux-de-joie*, and the rejoicings were continued throughout the day. Thus commences the life of the Princess Julia. These same guns which are now booming o'er the waters their noisy token of rejoicing, may at some future time be howling the discord of civil war on her account; these same bells may soon be sounding the alarm note, and again, the guns and bells may together sound her funeral knell. Truly, life is a vain shadow!

August 10.—At sea. What a change has within these ten days been wrought in our circumstances! We who a week since were enjoying summer weather, are now wrapped in our winter clothing and striving to keep out Jack Frost. Approaching Cape Horn, winter with its dreary storms is upon us; already are we contending with the furious antarctic blasts.

A most laughable scene occurred in our mess on the last night of our stay at Rio—I had nearly omitted it, but a good joke will not be out of place here, and it is a matter of regret to me that I cannot dress the story in such way as might do it justice. A gay young

widower of our mess fell in love with a fair maid of Brooklyn before we sailed. On the passage out he came to the determination to prosecute his suit, and on his return promises to invite us to his wedding. Meanwhile an opportunity offered itself at Rio to send some presents, and he purchased some of the most beautiful of Madame Finot's feather flowers; a bridal wreath was selected by some of us, and the assortment being ready it was necessary to prepare a letter. Several pages were soon filled with the outpourings of his heart, his effusions being interspersed with liberal quotations from Byron and other authors of celebrity. The letter ready, it was submitted to the inspection of the mess for criticism and correction; and there sat the critics, one reading aloud, the others commenting upon this passage, altering that, and expunging a third. The author was then set to work at the *fair copy*, which he transcribed and sent to its address. I enjoyed the scene more than I can express; the serio-comic manner of the lover, his singularity of ideas and eccentricity of expression were vastly entertaining.

The weather is chilly, raw, biting, cold and uncomfortable—miserable. Oh, what a dog's life is this of the sea! what an unnatural, entirely artificial and quite unreasonable life! Our friends at home are now suffering with the summer's heat, while we are biting our fingers with the cold off Cape Horn, in its last winter month. And that is not all: the wind is ahead, and has been so for the last three days; how long it may continue to oppose our passage to the Pacific is a matter of anxious inquiry in our minds.

How often have I looked on the Jack Tar with mingled feelings of wonder and pity!—wonder that a rational man should make an amphibious animal of himself, and expose himself to dangers and hardships that shorten his life one third; pity that the life of the noble seaman should be so hard, his comforts so few. By a computation of mine I judge that the tar does not on an average spend one twelfth of his time on shore; the rest of his life is spent in close imprisonment within the wooden walls of his ship. Seemingly with no ties, he appears to care for little beyond the present moment, and with a happy unconsciousness of the tranquil enjoyments of life, he seems content with and quite proud of his condition; ay, he looks with contempt upon the "poor landsman" who is compelled to "drudge away his life on shore." Truly in the seaman's case "ignorance is bliss."

August 11.—A number of beautiful birds, by seamen called the

"Cape Pigeon," have followed this ship for several days. In size, plumage and appearance they are almost the same as our tame pigeon, but seem as unwearied in their restlessness as the ocean itself—never alighting but for a moment to pick up a crumb from scraps thrown overboard. It is surprising to see them so ceaselessly on the wing; day and night they hover about the ship, hundreds of miles from land; blow high, blow low, they are ever here, and when the storm rages seem most gay and playful, and so untutored in the cruelties of man that they will flock around the ship to pick up the crumbs as we throw them.

August 18, 19, 20.—What bitter weather! A tremendous gale has raged these three days, with its wintry accompaniments of snow and hail and biting frost. The sudden change from the tropical sun to these icy regions has had a most painful effect upon us. My limbs are swollen and slightly frosted; my hands are really immense, and though the sensation is disagreeable, I have not experienced much inconvenience from it, though some of my mess-mates complain a great deal.

Saturday, August 22.—"Land ho!" is the cry from aloft, and at the sound, usually one of cheering import, all crowd on deck, not to see our expected port, not to see some green spot in the ocean, but to gaze upon a desert, frozen, desolate island. Staten Land, with its snow-clad hills and rock-bound shores, is in the distance, a pretty background to the picture of inhospitality and desolation which surrounds us.

Sunday, August 23.—We had a most narrow and providential escape this morning in my watch. The latter part of yesterday we were becalmed, but in the evening a light air sprung up which wafted us along pleasantly through the night. At 4 A. M. I took the deck; from the course we were steering I felt some apprehension about being too near the land seen yesterday, and in my anxiety enjoined additional vigilance on our lookouts. My own eyes are so defective that I am obliged to see through the eyes of others. A treacherous current was rapidly setting us on to dangers while we were all enjoying the rest of security. Day was just dawning when the look-out reported "*Land on the lee bow, close aboard!*" A startling cry enough when one is in the dark and gropes about without knowing whether he may run into new dangers. With no more time for reflection than a sailor may take for himself, I put the ship's head about, at the same time summoning the captain on deck. As may

be supposed he came in an instant. "Where is the land?" said he. "I don't know, sir, I have not looked at it. *Haul*, men, HAUL—Away with those braces! I am getting her around, sir, I did not stop to see the land." "Ah there it is!" said he; "how strange! how can we have come in here?" The ship safe, I looked for the land, and through the dim twilight could well discern its gloomy shores, rendered more distinct by their snowy covering. What an escape! One hour more of night and darkness and what a fearful doom would have been ours! what a dreadful fate we were preserved from by a kind Providence who watches over all our ways and guards us when we sleep and dream of security. The bleak, desolate and snow-covered sides of the island wore a more dreary aspect when we thought of our escape. An uninhabited, unfrequented island, whose rocky cliffs frown defiance on the waters and seem the very picture of frigid inhospitality, was presented to our view by the rising sun, and all must have felt grateful to Him who saved us from its barren shores.

September 3.—A fine, fair wind wafted us beyond the cold and dangers of Cape Horn, and we have for several days been approaching our port, with hearts made each day lighter by the increase of comfort experienced in the more moderate weather. Last night I saw one of those rare phenomena, a lunar rainbow, the first I have ever seen; it was very brilliant and formed a perfect arch. Its duration, however, was very brief; like all other beauties it soon faded from view and was lost.

September 9.—Valparaiso. We arrived here yesterday, and the comfort, the real pleasure of reaching a port after a tedious and boisterous sea voyage is only appreciable by those who have experienced the privations and hardships of a sea life. For a day or two before our arrival we had more moderate and pleasant weather, and began to enjoy ourselves after all the storms and frosts were left behind. My frosted hands are becoming more comfortable, though still as red as beets and still rather tender. Yes, though the port be ten thousand miles from home, though it be Valparaiso, there is great satisfaction in reaching an anchorage, seeing new faces, rambling on *terra firma*, and finally, in fresh provisions, milk, butter, and good bread.

The appearance of Valparaiso, though somewhat picturesque, is not altogether agreeable to the eye. The city is built at the foot of some lofty hills which abruptly rear their craggy peaks on every side of the bay. No luxuriant forests cover their nakedness; none

of the beautiful verdure of Brazil is seen. A scanty growth of cacti is the only object which relieves the roughness of the surrounding scenery. Here and there on the sides of the hills where there is a sufficiently level spot, neat villas are seen, and their pretty gardens seem quite inviting; but we have no time for looking into all of these comfortable retreats; our stay is to be short, and we must take but a hurried glance on the place. The snow-capped tops of the Andes are seen in the distance proudly raising themselves toward the heavens, and the inland scenery must be magnificent, and I hope some of these days to be enabled to view it for myself. The population of the city is somewhere about ten thousand, and the climate is said to be the finest in the world. The natives seem to be most commonly tinged with Indian blood, for very few are seen who are purely Spanish in appearance, and those only of the upper classes.

We sailed from Valparaiso on the 10th and had a passage of fourteen days to Callao, during which we had a continuation of charmingly comfortable weather. On the passage I had for the first time in my life a good view of a whale, though I have frequently seen them spout in the distance. On this occasion the huge monster was quietly playing about our ship for more than an hour, sometimes throwing himself half out of the water, at others plunging into the depth of the ocean and disappearing for about ten minutes, and then gently rising he would blow directly alongside of us.

September 22.—Callao. The country in this vicinity is of very singular formation; an extensive plain borders on the sea, having a most gentle inclination towards the shores; the distant view is bordered by the mountain ranges. Lima, the once proud "city of the kings," stands on this plain about six miles distant, and is fully in sight from the bay, presenting quite an imposing appearance, with its spires and towers rising above the verdant plain. The town of Callao stands on the bay side, and being on a sandy tongue of land, is about as miserable a town as can be met with, filled with wretchedness and filth. The houses are mostly of one story, built of bamboo and plastered over, as this affords a cheap and substantial style of building in a country where the constant earthquake shocks would shake down the more solid architecture in use at home.

On the 24th I visited Lima. It was a holiday, the festival of Sta. Mercedes, the patroness of the army, and the turnout on the occasion was quite imposing, and was doubly interesting to us, as all of Lima was in the streets, and we thus had an opportunity of seeing

the novel and varied costumes and customs of the gay Peruvians. Let me first speak of our ride in the stage, with such a motley set of *compagnons de voyage;* for it was a gala day, and Callao seemed to be pouring all of its population towards the capitol. Men, women and children crowded into the stage until its insides, which proclaimed to the world seats for fourteen, could hold no more than the eighteen who were thrust in on top of each other; but all were merry, and the confusion of tongues was as that of Babel. The road was dusty and almost suffocating, for "it never rains" here, and for the most part lay through a well cultivated country. The most remarkable production I observed in the gardens was the orange tree, which attains a size beyond any I have ever seen, many of them being some forty feet in height. As we approached the city our elevation enabled us to look back towards the sea, and the prospect was beautiful.

The streets of the city were filled with troops, and the population all in their best array. At 11 o'clock the Cathedral bells began to sound, the procession formed at the palace and marched to the church, which was already so crowded that it was impossible for us to get in. At 12 the religious services were over, and the procession, with its reinforcement of churchmen in the shape of priests, padres, incense-bearers, banners and images, swept through the square, with the martial music of a fine band filling the air with its delicious sounds; women, with baskets of beautiful flowers beautifully arranged, walked at intervals in the crowded train; the smoke of incense ascended and perfumed the atmosphere, and there too were the *images*—the idols of Papal superstition. First of all was the image of Santa Mercedes in a gaudy dress gorgeously spangled with emeralds and brilliant diamonds; a crown of pure gold decorated her head, in her left hand she carried a pair of golden shackles and in her right a wreath of beautiful flowers, as if to offer us on the one hand the shackles of sin, and on the other the flower-strewn paths of virtue. This saint was mounted on a throne borne on the shoulders of eight stout negroes, whose black legs stuck out beneath the finery of her ladyship in rather a ludicrous manner. The cortege swept on and left me absorbed in reflection as to what should be the end of this idolatry which has so widely spread over the world. The streets were crowded with people of every description; the squalid Indian of Peru, in his tawdry finery, with his ugly and misshapen wife, and the proud, graceful descendant of the Spaniard were alike to be seen, as well as all of the various castes from different parts of the country,

grouped together without regard to rank or appearance. The costume worn by the ladies of Lima in the street is one of the most remarkable things to be seen here. A skirt of silk closely gathered from the waist to the hips falls in graceful folds to the feet (formerly it was gathered all the way to the ankles). This is the *saya;* their upper works are clothed in a silken hood, generally black, which is gathered about the waist and is drawn up over the head and shoulders, concealing all but one eye, which peers out and strives to do all the talking of two common eyes assisted by a smiling mouth; and this hood or shawl is called the *manta.* What could have given rise to so strange a dress I know not, unless the early inhabitants of this place had cause to watch their gentle ones and guard them from the rude gaze of man; but certain it is that Lima is one of the most licentious places in the world, so the women may be assisted in their intrigues by a dress which enables them to walk the streets incognita. In former days Lima was proudly termed "the city of the kings," but the dreadful earthquake of 1746 reduced it to a heap of ruins, and from the desolation which then swept over it it has never recovered. The houses in the principal parts of the city are of two low stories, and are built of unburnt brick, the external appearance being simply that of a Spanish town with narrow streets paved with smooth round pebbles, very hard to walk upon.

In the morning we went into the Cathedral, which is a rather imposing building with two fine aisles, but there is always so much of tawdriness in the coloring and gilding of these Spanish churches that the designs of the best architects are in a measure destroyed by the flimsy finery which is meant for decoration. In the aisles are the sundry niches or chapels dedicated to the various saintly persons worshipped in this holy place. I had the curiosity to read some of the Spanish notices which are posted on the gateways (for they all have an iron gateway) of these chapels. In one of them was a female figure badly carved of wood and dressed in gaudy colors, and on the gateway was a notice to the effect that "His Excellency the Archbishop of Lima hereby granted an indulgence of eighty days to any one who would contribute candles sufficient to supply this chapel for one month, for the sake of Santa Rosa." Santa Rosa is the patron saint of the city of Lima, and a boy (one of the attendants) came with his silver box to beg for a shilling for Santa Rosa. Out of the main building I went into a side chapel where they were chanting a funeral service over some unfortunate body who had died in ignorance. In

the midst of their chant one of the priests would turn round and say sharply to a negro attendant, "Why don't you ring the bell louder?" then again he would chant, while the negro would run out and ring his little bell, and coming in, would again be sent off in the same manner. I could not restrain my laughter and walked out. In this cathedral repose the remains of Pizarro, the bold adventurer who first planted the standard of Spain among the Incas.

I must not forget to notice a singular representation of the crucifixion. In a chapel of the cathedral where matins were being performed there was a "crucifix" of life size, on either side of which stood the Marys; the mother of Jesus was standing, dressed in a rich silk, with a handsome scarf hanging on her arm and a fine Canton fan in her right hand—she was very calmly looking on the unhappy scene before her. Our captain told me that in a church he had visited he saw a *black* Virgin with a white infant Saviour in her arms; this was for the benefit of black worshippers. I had heard of such things but never believed them before.

The population of Lima is estimated at about 60,000. The city is surrounded by a low wall, built in the last century as a protection against sudden attacks from the Indians. Through the centre of such streets as run from east to west there runs a canal or drain, of about five feet in width, into which all of the refuse and filth of the city is thrown. The atmosphere is mild and the climate considered generally very salubrious, the heat of summer being less than one would expect to find so near the equator. The average range of the thermometer in summer does not exceed 82° in the shade; this may in some degree be attributed to the way in which the city is built, that is, with the streets running from NE. to SW. and from NW. to SE., thus they are shaded at all hours nearly.

I left Lima on the morning of the 25th, mounted on a tolerably good horse, and arrived at Callao without accident, finding the saddle a much more agreeable mode of conveyance than the heavy and crowded omnibus.

September 29.—Sailed from Callao.

September 30.—Arrived at Payta, as wretched a town as the eye of man may rest upon. Here we wait for news from the United States, by the steamer from Panama, which may be expected on October 2. The small town of Payta, the seaport of Para, is built at the head of a capacious roadstead, and has a neighboring country which affords the most perfect picture of desolation that the world can produce.

Not a blade of grass nor a stunted shrub is seen; on all sides as far as the eye can reach nothing is visible but a sandy and barren plain, broken here and there by ravines caused by some convulsion of nature, for "it never rains in Payta," and the fissures in the sides of the hills are therefore not caused by refreshing showers. The water used by the inhabitants is brought from the distance of nine miles, and a regular trade is carried on in the commodity by negroes, with the patient ass laden with small breakers of water. The roads of Payta are much resorted to by whaling vessels, as fresh provisions and vegetables are quite cheap, though brought from a distance.

October 3.—In the morning the English steamer arrived from Panama, bringing news from home as late as August 8. We of course expected no letters, but the mere sight of newspapers afforded us much gratification, as the accounts of sayings and doings in one's own country must to the absent always prove a source of pleasure. We learn that the war with Mexico still continues, and that extensive plans are proposed against that insignificant and powerless state; we learn too that California has fallen into our hands, having been taken possession of by our squadron. The same afternoon we left Payta with a fine breeze for the coast of Mexico.

October 9.—Death has come among us and most suddenly has taken away one of our crew. While at breakfast, one of the men came hastily for the doctor, saying "The old cook has a fit." The worthy surgeon hastened out, and almost immediately returned, saying, "He is dead!" Poor old Clark! a most respectable colored man, who had spent his life in the service, and was universally a favorite because of his unvarying good humor and cheerfulness, always seeming contented and happy. I had had the morning watch, and when he came to the mast at half-past seven to report the tea-water ready, I returned his pleasant laugh and thought how cheerful he was. He was then quite well; in one short hour he was numbered with the dead, after an illness of not more than three minutes.

A burial at sea is always solemn and imposing; the little community on shipboard are as if they had lost one of their family. The messmates of the deceased perform the last offices over the body, which is sewed up in canvas, with one or two shot at the feet to make it sink; the boatswain calls "All hands bury the dead!" and when the officers and crew are assembled at the gangway, the body, covered with a flag, is brought on a board, and there amid the silence of the

ocean the prayers are read and the body committed to the deep. The plunge is heard, the waters close over, the ship glides on; none but the eye of the Almighty can point out the spot where, embosomed in the ocean's wave, rests the body of the deceased. This seems like eternity!

October 22.—Nothing of interest has occurred during the past two weeks, which have been only remarkable for calms and light airs; but to-day we had another death on board. One of our seamen, a Swede, who has for several weeks been struggling against an attack of dysentery, has at last sunk under the disease and gone to his final account. The poor fellow was one of our best men; he had been more provident than seamen in general and had saved a small amount of money, which is deposited in a New York savings bank. With a feeling of gratitude toward our excellent surgeon, who had given him most unremitting attention during his tedious illness, he made a will in which he declared the doctor his heir, leaving him all that he possessed.

October 26.—For many, very many days we have been suffering with the intense tropical heat, which has been rendered more than usually uncomfortable by the continued calms or light airs of the region through which we are passing. In the past ten days we have scarcely moved one hundred miles, having had barely air enough to blow out a candle; and now we are on a short allowance of water.

October 30.—Still becalmed; still suffering with heat and for lack of water. The vicissitudes of climate, the sudden changes of season, the toils, the suffering, the exposure undergone by the mariner may justly be thought enough to break down a constitution of iron, and so indeed it is. Sailors are dissipated when on shore; for the delightful pleasure felt by those just returned from a long sea voyage, the comforts placed within the reach of those who have been so long subjected to privations, are greater than the weak mind of man is able to resist, and as the famished man will surfeit himself when food is placed within his reach, so will the seaman wholly give himself up to the pursuit of pleasure when on shore; and I do not wonder at it. Scarce six months have passed since I joined this ship, hardly five months have elapsed since we sailed from home, and yet we have passed through all the seasons of the year and are now in our second summer's heat. We left New York when the sun of June was high; we crossed the equator when it was winter there (although warm enough for us). At Rio spring was approaching; off Cape Horn

the blasts of winter were right rudely sounded in our ears; spring had come when we reached Callao, and summer too before we again reached the equator, and we now have the autumn of the northern tropic.

November 8.—Last night we were again mercifully preserved from a great danger. For several days past, having been favored with light winds and pleasant weather, we had made some progress towards our port and had just entered the mouth of the Gulf of California. We were running in for the land, with a light wind and all unconscious of dangers near; the friendly moon cast her pale light over the bosom of the deep and enabled our lookouts to see a rock lying directly ahead and very near us. The course was altered, and thus were we again saved from wreck by Him who watches while we sleep.

Saturday, November 14.—This afternoon we looked in upon Mazatlan. The ship anchored about three miles from the town, which presents quite a pretty appearance from the water; but, as sundry hostile demonstrations were made by the Mexicans, we of course held no communication with the shores. Our object in touching here was to obtain news of the squadron, as we hoped to find some of our vessels in port, but in this we were disappointed; there were no men-of-war except three Englishmen, to one of which I was despatched in a boat. We could plainly see from the ship that there was considerable excitement on shore on the occasion of our appearing off the harbor, and as I had to pull within gunshot range in approaching the British vessels, I expected every moment to see an iron messenger sent from the town after my boat, but nothing occurred to give excitement to the trip. I returned to the ship without any interruption and without news of our squadron, so we sailed immediately for the westward.

Monday, November 16.—This afternoon we came to anchor off the Bay of San José, a small village of Lower California, about twenty miles to the northward and eastward of Cape St. Lucas. Before the ship anchored I was sent in an armed boat to effect a landing, ascertain what was the disposition of the inhabitants, and endeavor to procure supplies of fresh provisions and water. We were getting so low in this last article that to-day we commenced an allowance of two quarts per man. As I approached the beach I saw the people gathering from all directions and forming a small squad at the only place where there seemed any chance of landing through the surf,

which was running very high. Not knowing what might be the feeling of this part of the Mexican people toward us, I thought that some trouble was in store, but as I could see with my glass that they were not in much greater force than my own party of fifteen fully armed, I pulled on through the surf, jumped out, waded on shore, and was glad to find that we should be able to procure all the necessary supplies without bloodshed.

On the beach was a gentleman, one of the resident Americans who had been expelled from Mazatlan on the commencement of the war. He assured me that all the Californians were friends of ours and that the people of San José were his personal friends. He had brought his horses to the beach, and I mounted one of them, caparisoned in gay Mexican housings, and off we rode for the village, about two miles distant. Our worthy purser, Mr. Buchanan, was in company, and I left him to make his arrangements for supplies of all kinds, having only remained myself for a few moments to greet an American lady and her pretty little daughter, and soon found myself on my way off to the ship. We gained here the first news of our vessels, the Cyane having visited the place only three days before on a cruise, and we heard with infinite satisfaction that some of our officers on the station have had opportunities of distinguishing themselves.

Friday, November 20.—Sailed from San José for the westward and the Californian coast.

December 21.—Bay of San Francisco. Before saying anything of this place, I must go back a little and speak of occurrences which passed since my last date. On the 12th we made the high land off Monterey and ran into the bay the same morning, the wind blowing nearly a gale, but as we saw no men-of-war we did not come to anchor. In standing out to the northward and westward, the weather being very thick and the rain pouring down in torrents, we came very near running on a low point of land forming the north point of the bay, but fortunately it was seen in time for us to save the ship. We were obliged to haul by the wind, which by this time increased to a gale and suddenly shifted to the northwest, blowing very heavy. Our situation was now one of extreme peril; on neither tack could we clear the shore. Night came on; we could not regain the port; the rain poured down in violent squalls, and the wind at times raged furiously; the lee shore was by a calculation not more than nine miles off. We could not carry much sail, and were obliged to reduce what little we had, on account of the violence of the squalls. A tremendous

swell set in from the southwest, and we felt that it was fast driving us toward the fatal shore. But the Almighty rendered us assistance and extricated us from the danger where the hand of man was powerless.

At 8 P. M. I took the deck for the first watch ; it was pitchy dark, and the ship, under a press of sail, struggled against the storm. Man, I felt, could do nothing, but a gracious God "stilled the tempest." Soon after I went on deck I found that the wind was moderating, though the sea ran so high that we could make no way against it. My watch was one of much anxiety and care, but the wind gradually changed, and during the mid-watch we were enabled to haul off shore, and our ship was soon bounding off before a gale from the southeast.

On Monday the 14th we arrived at San Francisco Bay, and were just congratulating ourselves on having made so long a voyage without accident, when, in standing for the anchorage, we ran ashore. Here was work indeed! Fortunately no rocks were under us, but a soft mud bottom. Our boats were got out, but the exertions of our crew were not sufficient to relieve the ship ; the boats of the squadron, however, soon reached us, and after two hours' work the Dale floated once more and proceeded to the anchorage. We found the frigate Savannah, sloops Cyane and Warren, at anchor, all heartily glad to see us, and all sick enough of this part of the world.

In the month of July last a revolt took place in California, and a party under Captain Frémont, calling themselves the Bear party, composed mostly of settlers in the neighborhood of Bear river, marched against the authorities of California. Various outrages were committed by both parties, the one desiring to overturn and the other to retain the legitimate power. At this time Commodore Sloat was here with the squadron, and supposing that the mass of Californians were ripe for revolt and ready to throw themselves into the arms of the United States, he hoisted the American flag and proclaimed the whole of California to be under American jurisdiction and protection. At this juncture he was relieved by Commodore Stockton, who within ten days of the first proclamation by Sloat issued another of similar import in his own name. Liberty was promised and also protection to private property; the religion and municipal regulations of the people were to be respected, and, in short, nothing was to be required of California but to become a part and parcel of the United States. Unfortunately, the promises held forth in the proclamations were outrageously violated; a party of volun-

teers broke into the church at San Juan, robbed it of whatsoever was valuable and maltreated the priest; in another place, women had been barbarously and brutally treated; horses and other private property were seized, as was said, for the use of the Government; a paper published in Monterey by Colton, a chaplain of the Navy, and by appointment Alcalde of Monterey, came out in violent terms against card playing, fandangos and horse racing; heavy penalties were threatened against those guilty of the above crimes, and a heavy excise duty was also imposed. All of the above circumstances aroused the indignation of people who could not tamely see their rights thus invaded and themselves stripped of their possessions.

Previous to the organization of the Bear party there existed two parties in the country; the stronger one was in favor of asking English protection, the other desired American, and the Bears by making a first move hoped to anticipate and settle the matter. There also existed a small but very respectable party, consisting mostly of those in power who desired no change; but all seemed in a state of tranquillity under American domination until the various acts spoken of above roused the indignation of both of the parties who were opposed to the Bears and their friends of the American squadron. While all was thought to be quiet throughout the province, a deep rooted and bitter feeling of hostility was fastening upon the minds of those who thought themselves outrageously wronged. An insurrectionary movement broke out in the south, and while Commodore Stockton was here he received intelligence that the garrison at Puebla was in danger, and that the forces landed at San Pedro, by Captain Mervine, to protect and hold that place, Puebla having been evacuated, had been driven off. The spirit of resistance spread rapidly throughout Upper California, and small parties were everywhere in arms against the Americans. The military posts were threatened, and cattle and horses were driven into the interior, in order not only to cut off our supplies of fresh provisions, but also to deprive our men of means of pursuit in a hilly country which can only be traversed on horseback. A formidable tribe of thieving Indians also gave trouble, and it was necessary to bring them over to our side. Purser Fauntleroy with fifty mounted men was despatched on this business, and after one or two skirmishes brought them to terms of alliance. Commodore Stockton, in the Congress, departed with haste for San Diégo, where troubles had also commenced. The Savannah returned to San Francisco, and Mervine became the Military Commandant of the Northern Department of California.

The above brief summary brings the reader to the time of our arrival in the Dale. We found the little town of Yerba Buêna, garrisoned and fortified, in the possession of the Americans; a post had been established at San José, about 50 miles to the SE., and another at Sonoma on the Sacramento. These garrisons are composed of seamen and naval officers; the one at San José being under Lieutenant Robt. Pinkney, with sixty men, and that at Sonoma under Lieutenant Maury. Lieutenant Bartlett, of the Navy, had been appointed Alcalde of Yerba Buêna, and Commander Hull commanded the post. The Alcalde held his courts unmolested, and decided upon the most intricate and difficult questions of Spanish law; disputed land claims were settled by him, and his decision was in all matters final. Lieutenant Bartlett gave much offense by some of his legal decisions, and he also, when seizing upon some property for public use, refused to give such acknowledgments as might enable the owners to recover from the Government the price of the article taken.

A man from the country was arrested and thrown into prison because his name was Sanchez and a person named Sanchez had rendered himself very conspicuous in his hostility to the Americans. The Alcalde one day ordered out his guards for a foraging party and rode some few miles from the town for a supply of cattle, taking with him money to purchase bullocks. He fell into the hands of the Sanchez family, and they measured out to him the same justice which he had been meting to them and their countrymen. He is closely detained as a prisoner, and they have refused to exchange him on any account.

Whilst affairs are in this state the squadron is sadly straitened for provisions; our supplies are nearly exhausted, and of bread our stock is so short that the men have been for some time on the daily allowance of but 10 ounces. A contract had been made with a Frenchman at Santa Clara to supply a small quantity of hard bread, some of which had been delivered; intelligence was received that the rest of the bread was ready, and the senior officer assigned it to the Dale, as that ship was ordered to get ready for sea. Santa Clara is a small village about 50 miles from Yerba Buêna, situated on a small river of the same name which discharges into the southeastern end of the bay of San Francisco. I was detailed for the duty of bringing off this bread, and on the night of Thursday, December 17, left the ship in the launch of the Savannah, with two midshipmen and a party of

marines and seamen numbering thirty, all well armed. It was reported that a strong body of Californians were lurking in the neighborhood, and we apprehended that an attempt would be made to intercept the bread and cut off our party; so I left the ship with full expectation of some interesting anecdote to relate on my return. I determined to bring off the bread if possible, and at all events not to be taken alive.

We left the ship at 7 o'clock in the evening and pulled down the bay until 1 A. M., when, the tide making strong against us, I anchored. In an open boat crowded with men and various stores sleep was out of the question, nor did I desire to sleep, being too much occupied with busy thought, and being anxious too to be ready with the earliest change of tide. So I wrapped myself in a boat cloak and lay down to await patiently the coming of day and the flood tide. My worn-out crew were soon asleep, until the gray light of morning appeared, when I called all hands to ply again the "lab'ring oar." The tide was just turning, and as we had a long distance to pull, it was important to make the best use of our time. The day shone out beautifully, and our cook managed with dexterity to give us a good breakfast, that is, a cup of hot coffee, cold meat, and bread. After pulling about 45 miles from the ship we entered the creek of Santa Clara, which is so very crooked that it is 15 miles from the entrance to the landing, though not more than one third that distance across the lowlands through which the creek runs. These lowlands are perfectly level and are not overflowed by the tides, although so nearly so as to be quite wet; their extent in breadth is at least six miles, being bounded on each side by high ranges of hills, and as far as the eye can reach to the southward this flat plain seems to extend.

The creek was filled with water-fowl of every description. I never in my life saw them so abundant or in such great variety; geese and wild ducks actually covered the water, and when they rose their noise was startling; it was like that of an army shouting in battle as they did in olden time; it was some time before I became accustomed to it. The banks of the creek, also, were filled with curlew, plover, and snipe in variety, while black birds in immense flocks were feeding on the plains, and reed birds in abundance hovered in the tule grass which fringes the edges of the creek. I had my gun with me and could not resist the temptation of killing some game; but in my large boat, swept on by the rapid current, it occasioned so much loss of time to pick up a duck that I would not fire again, considering it

too great an interference with my duty. At 11.30 A. M. I reached the landing, and after making a kind of encampment on the bank of the stream, with muskets loaded and stacked for ready use, went to dinner. I had scarcely sat down to my roughly prepared feast when my lookouts reported a troop of horsemen coming down, and sure enough there they came at full gallop, not more than half a mile off. "To your arms, men! Form!" were the only orders, and in less time than I have taken to say it we were ready, presenting a very respectable front of thirty-five well armed infantry. The approaching troop dashed on until within about 80 yards, causing me to expect a charge of cavalry. They numbered about 12 men, well mounted and armed with rifles, but at proper distance they halted and their leader alone rode up to me. I now found them to be friends, a party of volunteers who, scouring the country, happened accidentally to be in the neighborhood; so we sat down again to feast without fighting. Dinner over, I despatched a messenger to Lieutenant Pinkney, whose party lay nine miles off, to request him to send the bread, and then prepared to make my party comfortable for the night. I made a tent of one of the boat's sails to keep the arms dry, and stationed two sentries for the night to guard our camp, collected a large quantity of wood for our camp fire, got our supper comfortably, and when 9 o'clock came lay down and tried to sleep under a tarpaulin in the boat. The cold, however, was too piercing, and after fruitless efforts to sleep in spite of my freezing feet, I crept out and got by the camp fire, where most of my men were collected to keep warm, and thus passed the night tediously enough.

I listened to the yarns spun by the men and patiently waited for day; the stillness of the night was broken only by the careless laugh of the seamen, the howling of the prairie wolf in search of his prey, or the tremendous noise of the geese as they rose disturbedly from their midnight roosts. Daylight at length came, and with it a warm and cheering sun—the chilling blasts of the night were soon forgotten over a comfortable breakfast and the prospect of a fine day. At about 2 P. M. the slow moving oxen came along, dragging a rude wagon with the bread, driven by three or four noisy Indians. We made quick work of taking in the bread and getting ready for our departure, and at 3 P. M. left the landing with a strong ebb tide on our return to the ship. I hoped to get out of the creek before night, but in this was disappointed, for at 6 o'clock we grounded, and were soon left high and dry on a bank extending quite across the creek.

After making arrangements for my men for the night, I lighted my pipe and looked out for the tide; at 11 the boat floated again with the flood, and without loss of time I roused the men up, in order that we might make the best of our way out. This was not an easy matter; the night was very dark, we could see with difficulty, and frequently grounded on the flats, but long before daylight we got clear of the creek. It then began to rain, the morning was very dark and our prospects gloomy; fifty miles from the ship—so much fog that we could not see the shores, and therefore were unable to take advantage of the favorable currents. I had a compass, fortunately, and by its aid succeeded in making a tolerable course. It cleared up at noon, and we had the satisfaction of discovering the shipping at anchor, and by one o'clock got alongside of the Savannah, after the shortest trip that had been made to the Santa Clara landing, and without having seen an enemy. I found that the Dale had dropped down to the anchorage at Saucelito to water and prepare for sea, so I had to go on, about seven miles further, before finishing my expedition, and reached the ship in safety at about 4 P. M.

Christmas Day.—At Saucelito Bay, an anchorage and watering place (not a place of fashionable summer resort, but a place to water ship), in a lonesome part of the great and beautiful bay of San Francisco. Here the good ship Dale is riding at her anchor, the wind blows a violent gale and the rain pours down in torrents. The day was kept by our mess as well as circumstances would permit. There was no merrymaking nor feasting, but a very good dinner for this part of the world, with our captain as our guest, and a glass of wine to our absent friends, while we wondered how many more Christmas days were to be passed ere we should be restored to them.

January 23, 1847.—Monterey. Yesterday at early morn we were cheered by the appearance of a sail standing into the bay; some variety was thus added to this dullest of all dull places; but the stranger soon proved to be a small coasting brig from San Francisco, with a very acceptable supply of bread for us, an article that is getting so scarce in these parts that flour is at $28 per barrel, and none to be bought even at that price. Our eyes were soon gladdened again by the approach of another sail, which we ascertained to be a man-of-war. She fired a signal gun and all eyes were strained, all glasses in requisition in order to discover who the stranger might be. It proved to be the Independence, and our hearts beat high with thoughts of letters from home. Slowly and majestically the proud ship came in,

and when at length our boat returned, the excited fellows crowded around in eager impatience to seize their letters.

Upper California.—As yet I have said nothing of California, a country so full of interest, at present, to us all in the United States. California was discovered in 1534 by an expedition sent by the famous Cortez. The Gulf of California was at this time called the Sea of Cortez, also El Mar Rigo (the Red Sea), from the discolored appearance of the water, caused by the waters from the Colorado river which discharges into it on the north. In 1602 a new expedition was fitted out for exploring the coast of California, by the viceroy, the Conte de Monte Rey. This squadron penetrated as far north as the harbor to which was given the name of the viceroy, and then returned to Mexico, having met with many obstacles and much bad weather. In 1697 the first settlement was made by the Jesuit Mission of San Dionysio, in Lower California. In 1720 La Paz, and in 1730 the Mission of San José were established. At about this time a most desolating hurricane is said to have swept over the land, destroying everything in its way, uprooting forests and laying barren the fruitful land. From the effects of this tempest Old or Lower California has never recovered. The Indians, according to the early discoverers, were mild and friendly, but living in a state of abject misery and barbarism, being far different from their neighbors the civilized tribes of Mexico. Vessels of clay were found among them, but no other utensils; the men were found in a state of entire nudity, and the females not much better off. The pearl ornaments worn by the Indians attracted the cupidity of the Spaniards, and many adventurers soon resorted to the northern shores of the gulf in search of these valuable ornaments; the Indians were pressed into their service and employed as divers, being most cruelly and barbarously treated by the whites. But little was done for many years towards the advancement of civilization, until at the time of the expulsion of the Jesuits from Mexico in 1769, some of these persecuted men fled to California and there established the mission of San Diégo. One year afterward the mission of San Carlos was founded at Monte Rey, and the course adopted by these fanatics in the pursuance of the civilization of the Indian cannot fail to excite the astonishment and disgust of all who view Christianity in its proper light. The Jesuit priests were well received by the Indians, and soon acquired over them that influence which superior minds invariably gain over those without intelligence; the lands became the property of the mission; the Indians, by an ingenious change of

term, were the slaves of the priest, and the produce of their labor was for the priesthood.

They procured from their Government in Mexico the exclusive right to the soil. No settlers were allowed except by permission of the missionaries, through whom grants of land were with difficulty obtained. The few soldiers who were sent by the authorities to serve as guards for the mission were not permitted to marry, and thus were prevented from becoming identified in interests with the land. By the severity of the priests such a state of activity was aroused among the poor savages that the produce of the fertile soil was most extraordinary, and the cattle brought by them increased with such rapidity that the revenues of the missions were beyond measure in value. The Indians were compelled, under penalty of being whipped and imprisoned, to attend the religious services of the church at the stated hours; converts were in attendance, too, with rods to flog those who were inattentive during the prayers, so that the chanting of the priests was accompanied by the scourge of the overseer and cry of the tormented, and this state of affairs was permitted to exist until a very recent date.

The Indians thus practiced upon were called "converted Indians," and parties of them were sometimes sent into the interior to bring in captured gentiles. These were forcibly brought to the mission, made to kneel, furnished with blankets, and when taught to repeat the names of the Trinity, in a language never before heard by them, were pronounced holy and baptized! Some would watch their opportunity and fly from their persecutors, but they were always pursued, brought back, and loaded with chains, until finding no escape they passively yielded to their fate—a slavery worse than death. Those exhibiting any reluctance to attend mass were imprisoned and thus brought to their senses.

The Indians of California were found in the most wretched condition of savage life, wanting in everything which makes man rational, tractable, and useful; they are described as stupid, inconstant, impetuous, gluttonous, slothful, and sensual; wandering in their habits, and living in miserable huts. Their food consisted of seeds and herbs made into a gruel or sort of bread; the seed of the pine was an important article of food and is still much used; fish, game, strawberries and blackberries are also used, and a bulbous root called *amole*, in appearance like an onion, is eaten, and used also for soap. Marriage among them was a singularly observed ceremony, for here

a man literally married the whole family, as the mother and sisters of his wife frequently became his concubines. The tribes in the northern parts were in the habit of burning their dead; those at the south buried their bodies. Their religion was paganism of the worst sort, though they made no human sacrifices.

The country abounds in wild animals. The American lion, ounce, buffalo, stag, roe, catamount, fox, wolf, bear, polecat, jackal, hare, rabbit, field rat, are found, as well as the otter and beaver, valuable for their furs and in great abundance. Vultures, eagles, falcons, and a great many other birds are found in the woods, and fish are abundant in the waters of the bays.

Since the revolution of Mexico the property of the missions has been in a great measure appropriated to public use and the land has been distributed among the people, while the priests are now obliged to confine their attention pretty generally to their legitimate calling. The settlers, who have at least three-fourths of Mexican blood, are called national people, while all others are classed with the poor Indians as beasts; but the condition of the nationals is little better than barbarism; they are ignorant, vicious, slothful, treacherous, and without stability of character or purpose, turbulent, and prone to disorder and revolution, and barbarously cruel in their treatment of the Indians. An instance of the last mentioned trait of their character was exhibited a few months since by a military party who, on an excursion to one of the northern provinces, visited an island occupied by a small portion of a neighboring tribe. The Mexicans were hospitably received and kindly treated by the Indians, and in return for this kindness the Mexicans, on some trivial pretext, atrociously slaughtered the whole of them, to the number of nearly one hundred men, women and children. All were inhumanly butchered; a mock baptism was first performed on the children and then their brains were dashed out; again, since the outbreak here, two of our countrymen who fell into their hands were most horribly mutilated and tortured till death released them from their ferocious captors. Such are the men who have, by a series of outrage and brutality, been governing this fair portion of the earth. It is devoutly to be hoped that in the hands of the Americans, to whom the sceptre has now passed, California may ere long rise to its proper place among the nations of the earth. Revolution and anarchy have been heretofore but daily occurrences in this land, stained with crime and bloodshed.

In 1836, during their insurrection against the government, the nationals called in the aid of some of the foreign residents, who, led by one Graham, cheerfully assisted Don Alvarado in overturning the legal authorities; but when placed in power, the Don thought his Yankee satellites too free and easy and proscribed them. From that time there has been a struggle between the immigrants, who began to feel their power, and the Mexican settlers. This has now been terminated by the occupation of California by the Americans.

I must not omit to mention some of the prevailing vices. The besetting sin is gambling, which, among the Indians in particular, prevails to an alarming extent and forbids all advancement. On Saturday night and Sunday the Indian will gamble away his week's earnings, and frequently they have become so absorbed in their game as to stake their clothing, beads, baubles, and even their wives and children. The better classes also are sorely addicted to this vice.

The Carnival, or *Carnes tolendas*, is celebrated for the two and a half weeks preceding Ash-Wednesday, during which time fandangos and all kinds of frolic are indulged in. Their favorite pastime, however, consists in breaking eggs. For this purpose the eggs are blown and the shell filled with ribbon and tinsel cut into most minute pieces; cologne or other perfumed water is then poured in and the aperture in the shell is stopped with wax. Thus armed, people of both sexes may be seen watching opportunities of breaking the egg over the head of the unwary. A scuffle sometimes ensues; the maid may be detected in her approach, and the young gallant has the privilege of disarming her if he can, and in this struggle he may search the damsel pretty thoroughly without giving offense.

One of our midshipmen had a curious game of this kind with a young lady, who finding herself reduced to extremities, unceremoniously thrust the egg in a place which quite baffled the gentleman, and the lady and her sister laughed heartily at his defeat. Yet the women are said to be chaste, and I doubt not they are so; their coarseness is attributable to want of education and from association with the vicious and unprincipled men who have always been the men of power in this country—for Mexico, by some blind mistake in her policy, has long been in the habit of sending the worst and most troublesome of her public servants to California; convicts, too, have been sent here from time to time, so that the society has been of the worst order. Chastity among the unmarried women is expected to be most rigidly observed, but with the married less reserve is thought

necessary. I could even tell of a spy who came into Monterey while I was there. The commandant of the post, through a secret agent, heard of him and his whereabouts and proceeded to the house to search for him. It was early, but the ladies had retired; the officer asked permission to look in their chamber, assent was readily given; two ladies were in bed—one of them sat up and talked with the officer. "Who is that between them?" said he to the husband. "It is Juanita" (*Joanna*). "Good night," said the officer; and the next day he was informed that the *spy* was the individual concealed in the bed between two ladies.

A very small portion of the soil of California is fit for agricultural purposes; it is estimated at not more than one-tenth of the face of the country, which is everywhere cut up by the mountain ridges; but the valleys are of surprising fertility, the yield of grain being almost incredible, one hundredfold being the common return of the rude labor of the husbandman. A fine variety of wild oats abounds in the uncultivated regions, and on this and the perpetual grass of the mountains the wild horses and cattle thrive astonishingly well. In the neighborhood of San Diégo the greatest variety of fruits are produced and excellent wine is made; to the south the country becomes more sandy, and but little attention is given to agricultural pursuits. Small quantities of sugar cane may be found near Cape St. Lucas, and when I visited that place a rough sugar mill was in operation.

[*To be concluded.*]

U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

FEBRUARY, 1888.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

By CHARLES E. MUNROE.

No. XVI.

Through the courtesy of Col. Majendie, C. B., H. M. Chief Inspector of Explosives, we are in receipt of a copy of his extremely interesting "Report on an Explosion at Roberts, Dale & Co's Chemical Works, near Manchester," which occurred June 22, 1887. This explosion was a very severe one, the local effect being as great as that produced by the explosion of 13½ tons of gun-cotton in the great Stowmarket explosion of August 11, 1871, while the force was felt for a radius of two miles, and the sound was heard distinctly at a distance of twenty miles. The effect was more marked and widely extended than in the case of the Regent's Park explosion of 1874, when five tons of gunpowder exploded.

Inquiry revealed the fact that the company were large manufacturers of picric acid and of lead nitrate. The picric acid is made by melting carbolic acid and mixing it with strong sulphuric acid, then diluting the sulpho-carbolic (or "phenol-sulphuric") acid with water, and afterward running it slowly into a stone tank containing nitric acid. The mixture is allowed to cool, when the crude picric acid crystallizes out, the acid liquid (which contains practically no picric acid, but only sulphuric with some nitric acid) being poured down the drains. The crude picric acid, after being drained, is transferred

*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

to the boiling "stones," where it is dissolved in water by the aid of steam, and afterward allowed to cool, when most of the picric acid crystallizes out. The "mother liquor" is then transferred to the precipitating tank, in which the picric acid still left in solution is precipitated by the addition of sulphuric acid. The picric acid left in the boiling "stones" is once more dissolved in hot water, and this second solution transferred to the crystallizing tank, where it is left to cool, and where the picric acid crystallizes. These tanks generally contained about 130 lbs of picric acid. Finally the picric acid, after draining in the tank, is transferred to a centrifugal machine to remove the excess of moisture, and then dried on glazed earthenware trays in a steam-heated stove in which the temperature was not allowed to rise above 100° F.

The circumstances of the explosion were as follows: About seven or eight minutes before noon a fire broke out near the picric acid stove which spread with great rapidity over the works. After a lapse of about five or six minutes there was an explosion of a moderate character from somewhere about the stove, and a minute after this a second explosion occurred of a most tremendous and destructive character.

Investigation revealed the fact that before the fire there was in the immediate vicinity of the stove some 13 to 14 cwt. of picric acid, and a considerable quantity of litharge, of lead nitrate, and of strontium nitrate, any one of which would, when mixed with picric acid, according to the experiments made, form a detonating mixture; while not far off was a stone crystallizing vessel containing some 130 lbs. of picric acid crystals, probably wet; and that some few minutes before the fire broke out a man who had been smoking a pipe knocked the ashes out near the stove.

From a consideration of these and many other circumstances, Col. Majendie concludes:

1st. That the accident originated in a fire (either at or in the immediate vicinity of the stove), and that such fire was caused by the workman either in lighting, smoking, or "knocking out" his pipe.

2d. That the first or minor explosion probably occurred inside the stove, and whether due to the bursting of steam pipes, or to the explosion of some material present in the stove or formed in the course of the conflagration, was a direct result of the fire.

3d. That the second or main explosion was due to the detonation of a quantity of picric acid and self-formed picrate of lead (or other

detonative compound), and that this detonation effected the simultaneous detonation of the picric acid in the crystallizing vessel, the whole being the result of the fire.

In the course of this inquiry great differences of opinion were found to exist as to the explosiveness of picric acid ; the books stating it to be explosive by heat, while the various manufacturers claimed that it could not be exploded in this way even in large masses, and they supported their claim by citing instances where as many as five or six hundredweight, packed in bulk in a dry cask of light wood and exposed to fire, had burned away without explosion. The experiments made on this point by Sir F. Abel, Dr. Dupré, and Col. Majendie, gave results which supported the views of the manufacturers, yet Col. Majendie is not prepared to go so far as to assert that under no circumstances can unconfined picric acid be exploded by the action of fire.

There exists no doubt, however, that picric acid is liable to be exploded by detonation or by a blow, and that the picrates and the mixtures of picric acid with oxidizing agents are highly explosive. So far back as 1873 Sprengel remarked that " picric acid alone contains a sufficient amount of available oxygen to render it, without the help of foreign oxidisers, a powerful explosive when fired with a detonator. Its explosion is almost unaccompanied by smoke."*

Apart from this inquiry, the detonation of picric acid has recently attracted interest, from the alleged use by the French Government of this substance, in a particular fused and consolidated condition, as an explosive, under the name of *mélinite ;* and an English patent (No. 15,089, Dec. 8, 1885) has been taken out by Mr. A. M. Clark on behalf of M. Eugène Turpin of France, which claims the employment " as an explosive agent for military or other uses, of the trinitrophenol, or picric acid of commerce, unmixed with any oxidising substance," by the use of a powerful fulminating detonator, or by the use of an intermediate priming of picric acid in powder primed by the fulminate, or by dispensing with the fulminate and employing a sufficiently large charge of ordinary quick-burning powder enclosed in a strong tube and made to burst inside the charge of picric acid.

The explosiveness of picric acid by detonation and by a blow was also experimentally studied by the gentlemen above mentioned, and they find, 1st, that dry picric acid may be perfectly detonated by

* Jour. Chem. Soc. 9, 803 ; 1873.

means of a 5-grain fulminate detonator; 2d, that the detonation of a small quantity of dry picric acid is capable of detonating a quantity of picric acid placed at a short distance from it; and 3d, that the detonation of picric acid containing, at any rate, as much as about 17 per cent of water may be effected by detonating a charge of dry picric acid alongside it.

The experiments with blows showed that when thinly spread, dry powdered cold picric acid will be exploded by a weight of 54 pounds falling 20 feet, and may be by a weight of 1 pound falling 26 inches. The sensitiveness greatly increases with warming, so that when near its melting point (say 240° F.), a weight of 1 pound falling 14 inches will explode it. It was easily exploded in this state by the blow of a light hammer (14½ ounces with handle) on an anvil.

Mr. Peter van Brock, of Roslyn, N. Y., publishes in the *Mechanical News*, Nov. 15, 1887, a letter on the subject of firing dynamite from gunpowder guns, which he had addressed to Col. J. Hamilton, U. S. A., March 18, 1884, and to which he adds some further comments. He says: "Permit me to inform you and all interested, that dynamite has already been used as a shell-charge in the ordinary service-shells known as James, Hotchkiss, Rodman, and Parrott, and that with absolute safety and success in the years 1862, 1863, and 1865, the last official notice and firing having been granted by Gen. Ord, and the shell so loaded with chemically compressed dynamite fired from a 4.5 inch Rodman rifle, at Fort Powhatan on the James River, on or about the 20th of March, 1865. The officers in charge of the firing were a captain or major named King, and a chaplain in some regiment of the 24th Army Corps whose name I forget. I was the sole witness on the part of the inventor, but there were present at least one hundred officers and enlisted men. I can lay my hands speedily, if you want them, upon the three shells remaining from that trial; the inventor will, I am sure, be glad to be rid of them, as they are fitted with Schenkl percussion fuse, with wood pins in place of brass, for more sudden explosion.

"And I have fired them myself from an old musket, .69 calibre, that is to say, brass shell containing 100 grains C. C. dynamite, said shell taking the rifling.

"As to the statement that dynamite always explodes downwards, that is another popular fallacy. All such explosives as nitro-glycerine, gun-cotton, and the fulminates in general, exert their force in

the direction of the greatest resistance. Dynamite exploded on top of a plank splits it to atoms; place it against a vertical plank and the same result follows, and if hung in a bag against the under side of a plank, you find the plank in fragments as before. Dynamite also operates best in close masses, not more than two diameters of the mass in length thereof.

"One of the shells of which I have spoken tore a hole in the side of an old hulk filled with cobblestones, big enough to drive a dirt cart through, clear. A 12-pound James shell, real weight 16 pounds, and containing only 12 ounces of this material, tore a hole in common rock (such as exists at Yorkville, New York City) big enough to hide a 42-gallon barrel in. Another of these last, exploding on the water, produced a pretty solid hailstorm, half a mile diameter. A 30-pound Parrott covered with its fragments a circle a mile in diameter—dynamite charge 19 ounces. Another, fired to penetrate a 6-inch iron plate, exploded there, making a hole big enough to run the muzzle of an 11-inch Dahlgren through. And judging by all I have seen done, there is not any vessel now afloat, with the sole exception of the Italian monster ironclads, that could remain afloat five seconds after receiving one dynamite shell from a 16-inch rifle.

"It is an absolute fact that no *pure explosive*, whether liquid or powder, can be used as a shell-charge in the front of such powder charges as are perfectly safe with powder shells. And yet I have seen the common shell explode prematurely, at or near the muzzle of the gun, and had them explode in the gun; but these accidents are the fault of the fuses, and not the charge. Moreover, one of these very dynamite shells broke up in the gun under my hand and went out like grape, and yet the compressed dynamite did not explode; if it had, this letter would not have been written. Another dynamiter exploded at a hundred yards from the muzzle, but the gun charge was so large that the fragments did not fly back.

"This time we were able to prove that the fuse was in fault, for it was found in a tell-tale condition, although tolerably well crushed up. These ill results led the inventor to construct a fuse that would always explode on meeting an obstruction, a piece of half-inch pine board, a foot square, hung by two strings, sufficing to work the fuse; or it could be changed in 15 seconds to pass through 6 inches iron and 30 inches spruce plank and explode behind them.

"The United States is not in the defenseless condition so harped upon by the papers endorsing Zalinski and his methods, which are

highly dangerous to the users if there were any enemy around. He cannot operate much over three miles, while our (common ordnance rifle) side can operate at from seven to twelve miles range, and our first cost is not a fiftieth of his, and fifty times more effective, while absolutely safe for the gunners.

"It will be observed that Graydon has used the same calibre that we last operated with, the 4½-inch siege gun—so he is 22 years behind-hand anyhow. Of course commercial dynamite can be used if it be not kept too long in the shell before firing, its safety against shock and friction being amply shown by Nobel's first public experiments therewith. To have such shells explode on striking, without a fuse, means that they were left head downwards for a few days; then enough pure nitro-glycerine would drain out of the dynamite to form a *per*cussion, though not a *con*cussion fuse."

One naturally inquires when the dynamite used in 1862, 1863 and 1865, in the above described experiments, was invented, and we hence note here the statements of several well known authorities. Thus we find in *A Treatise on Explosive Compounds by Henry S. Drinker* (John Wiley & Sons), 1883, an extensive chronological table containing the most important events concerning explosives, and on page 55, in small capitals, to make it especially prominent, we find "1867—Nobel invented dynamite." *Johnson's New Universal Cyclopaedia*, Vol. I, Part II, 1882, contains an article on "Explosives," written by Gen. H. L. Abbot, in which we find, page 1687, "Dynamite, called in the United States 'giant powder,' was invented in 1866–67 by Nobel." In the article on "Explosives," by Prof. Walter N. Hill, published in *A Naval Encyclopaedia* (L. R. Hamersly & Co.), 1881, we find on page 263, "In 1866 dynamite was brought out." In the *Traité sur la Poudre et les Corps Explosifs* by E. Désortiaux, from the German of Upmann and Meyer (Dunod), 1878, we have Vol. 2, page 698, "Nobel fut encore le premier qui, vers la fin de 1866, parvint à la transformer en une masse solide et à l'introduire dans le commerce sous le nom de *dynamite*." The *Handbuch der chemischen Technologie* by Drs. P. A. Bolley and K. Birnbaum (Friedrich Vieweg und Sohn), 1874, says in No. 23, page 66, "Nobel war wiederum der Erste, welcher gegen Ende des Jahres 1866, dasselbe in fester Gestalt als Dynamit in den Handel brachte." *The Modern High Explosives*, by Manuel Eissler (John Wiley & Sons), 1884, states on page 39, "Dynamite was applied for the first time for blasting operations in the

year 1866." *On Modern Blasting Agents*, by Alfred Nobel (Maclehose and Macdougall), 1875, page 9, we learn that "It was then proposed and adopted as a temporary measure to render nitro-glycerine inexplosive, or rather much less sensitive, by adding methylic alcohol, in which it readily dissolves. On shaking it with water, which takes up the alcohol, the explosive properties are fully restored, and the same detonator cap, which has not the slightest effect on the mixture of nitro-glycerine and wood naphtha, explodes it after a moment's washing with water. That method of protection against the danger of nitro-glycerine, although much patronized by chemists, had many drawbacks, and was troublesome for miners to adopt. It was really never intended for general use, but only to serve until solidified nitro-glycerine, known under the name of 'dynamite' (in America, 'giant powder'), and invented already at an earlier date, could be adapted for practical use. That took some time, and the article was not put up for sale until about June, 1867." Finally, in *Sur la Force des Matières Explosives*, by M. Berthelot (Gauthier-Villars), 1883, Vol. 2, page 207, we find: "En 1866, à la suite d'accidents effroyables causés par des explosions de nitro-glycérine (Stockholm, Hambourg, Aspinwal, San Francisco, Quenast en Belgique), l'emploi de cette substance allait être partout interdit, lorsqu'un Suédois, M. Nobel, imagina de la rendre moins sensible aux chocs en la mélangeant avec une substance inerte, artifice bien connu pour atténuer les effets de la poudre ordinaire, mais qui conduit dans le cas actuel à des resultats inattendus. M. Nobel y ajouta d'abord un peu d'alcool methylique; puis, cet expédient étant insuffisant, il le mêla avec la silice amorphe. Il designa ce mélange sous le nom de *dynamite*."

The *N. Y. Daily Graphic*, Jan. 23, 1888, describes with illustrations some experiments recently made by the Turkish Government at Agha Deressi, in firing explosive gelatine from gunpowder guns by means of the Snyder* projectiles. The piece consisted of a 15 cm. breech-loading rifled howitzer. The target, erected at a distance of 200 metres, was composed of twelve one-inch steel plates welded together and backed with oaken beams 12 by 14 inches thick. It was 4 feet 6 inches high, 14 feet 6 inches wide, and weighed altogether over twenty tons, including the massive frame of supporting beams in the rear. The shell was charged with ten pounds of the explosive, consisting of ninety-four per cent of nitro-glycerine and

* Proc. Nav. Inst. **12**, 617; 1886, and **13**, 411; 1887.

six per cent of a mixture of collodion gun-cotton, camphor, and ether. It is claimed that this explodes by mere percussion against a hard and solid body. The above described target was overthrown by a single shell. The photograph of the destroyed target probably does the experimenter an injustice, as from the position of the fallen target and the appearance of the backing it seems as if the support had not been sufficient for the weight of target put upon it.

The report of the army ordnance officers on the experiments made at Sandy Hook last December in firing dynamite shells from a rifled gun and with the regular powder charge has been made public. The Board consisted of Lieutenant-Colonel A. Mordecai, Major J. P. Farley, and Captain John E. Greer. In their report to General Benét, Chief of Ordnance of the United States Army, they say the testing target was totally wrecked. It was a wrought-iron semi-circular turret, eighteen feet wide, ten feet high and fourteen inches thick, made of two seven-inch plates closely assembled and riveted together with heavy bolts. The damage and disruption were done by three dynamite shells fired from a seven-inch Ames rifled gun. The shells were of steel, weighed 122 pounds, and were charged with two and two-thirds pounds of dynamite. Three demonstrations of this invention have thus far been made by order of General Sheridan—two at San Francisco, in the summer of 1886, and the third at Sandy Hook. The experiments at San Francisco were conducted by General O. O. Howard, and were intended merely to demonstrate that shells charged with dynamite could be fired from cannon without premature explosion. After fifty-eight dynamite shells had been successfully fired out of a three-inch and four and one-half inch siege gun from the Presidio grounds into the hills across the Golden Gate, the board of officers conducting the experiment expressed the opinion in their report that the two principal causes—apprehensions of danger from heat and shock—had been completely guarded against. General Howard then recommended further experiments with larger guns, and out of this recommendation grew the Sandy Hook demonstration with a seven-inch Ames gun and 122-pound shells. The San Francisco experiments had proven that dynamite shells could be fired from cannon with safety, and at Sandy Hook it was intended to prove that dynamite shells possessed still another important merit — that of obtaining penetration before explosion.

The effect of the three shots fired there is minutely described by

the Board in their report. The first shell which struck the target was a glancing shot, and not a "point on" shot, as was desired to test the penetration. It made an indenture, nevertheless, three inches deep, exploding with great violence. The Board says:

"The roof of the turret, weighing 30,900 pounds, was lifted off and blown twenty-five feet to the rear, breaking seven bolts, each one and three-fourths inches in diameter, used to assemble the same, and five bolts three and three-fourths inches in diameter used to bolt the front and rear plates together. It also made a crack ten inches long in the front plate and about eighteen inches long in the rear plate. The wreckage was very marked. The two seven-inch plates of the turret proper were also torn apart a distance of five inches, breaking off the bolt heads which secured the plates together."

The result of the second shot, as stated in the report, was as follows:

"The shot struck in a mark one inch deep that had been made by an empty cast-iron shell, deepening the impression to three and one-eighth inches sixteen inches below the first shot. It continued the crack made by the first shot upward to the top bolt holes and downward to the horizontal joint, the length of this crack being five feet two inches. This was also a glancing shot, the same as the first."

The wreckage produced by this shot was even greater than that of the first, the two seven-inch plates forming the turret proper, which were torn apart by the first shot, being torn still further apart to the extent of seven inches. Numerous bolts were also broken and displaced, and the rear plate cracked from the embrasure to the bottom of the turret.

The third shot penetrated the first plate seven inches and the second plate one inch. The front plate was broken, a piece two feet eleven inches by three feet three inches being thrown eighteen feet to the left of the target. The cracks in the rear plate were opened, five new cracks made about nine inches long, and the plate opposite the point struck bulged out to the rear three inches. The shot completely destroyed the left side of the target, the penetration of the front plate being effected before the explosion of the dynamite, and its wrecking energies being entirely exerted on the turret. The weight of the piece blown out was variously estimated at from one and a half to two tons. The two main seven-inch plates composing the turret were also still further separated and numbers of bolts blown off.

At this point it was deemed useless to fire any more at the wrecked turret, the section of the target fired at having been virtually destroyed

by three ordinary steel shells filled with less than three pounds of dynamite.

The main points of merit thus substantiated were:

1. To fire a dynamite shell from a heavy rifled cannon with the full service charge of black powder as the propelling force without injury to the cannon.

2. To obtain full penetration* by the shell before the dynamite was exploded in the target.

Four other shells were fired on this occasion at different ranges, one reaching the full range of the cannon, estimated at four and a half miles, out to sea.

Other experiments with the largest guns in the service, and with twelve-inch rifled mortars throwing 625-pound shells a distance of five and a half miles, and with the Hotchkiss revolving cannon, will soon be made to still further test the merits of this method of charging shells with dynamite.—*New York Herald*, February 6, 1888.

In the "Story of the Assassination of Alexander II," by J. E. Muddock, after describing the organization for this purpose and speculating as to why the special method used was selected, he says: "But this much is certain: a student in the School of Chemistry at St. Petersburg sent to the committee in Paris a formula for the preparation of an explosive compound. This compound, while having glycerine as a base, was not what is commonly known as nitro-glycerine, but was infinitely more powerful than even that powerful explosive. It was stated that so small a quantity as two drachms, confined in a steel tube, would, on being exploded, kill every living thing within a radius of twelve yards. What became of the inventor of it is not accurately known, but he is supposed to have drowned himself in the Neva. The reason the explosive was not prepared in Russia was owing to the difficulties there were in the way of procuring the ingredients without arousing suspicion. The bombs themselves, however, were manufactured in St. Petersburg. And this important work was placed in the hands of one Keebalchich, the son of a priest. This man had studied for the Church, but had subsequently entered the School of Government Engineers."

He displayed much ingenuity in making these bombs, which "were conical in shape; the conical end being so weighted that, on falling, that part of the bomb was sure to strike the ground first. In the

* Proc. Nav. Inst. 11, 291; 1885.

extreme tip of the shell, and also in a circle round the end, percussion caps were sunk. These in turn communicated with a slender steel tube that extended from tip to base of the shell. This tube was filled with the explosive to which allusion has been made. It was a clear amber-colored fluid, but thick like golden syrup, and sweet to the taste. A few moments, however, after it had touched the tongue, a painful, burning sensation was experienced. If two or three drops of this stuff were allowed to fall upon a hot stove they instantaneously produced an enormous and blinding sheet of brilliantly white flame. But there was neither noise nor smoke, though a peculiar odor was evolved that resembled that of burning leather. Round the steel tube blasting powder was rammed very tightly, and between the powder and the wall of the shell was a thin layer of gun-cotton. At least half a dozen of these formidable engines of death were manufactured, together with some of a more ordinary kind, while two were made of glass filled with dynamite."

The fatal bomb, thrown by Elinkoff, the conspirator, who was only a few yards away, "fell at the Czar's feet, but, strangely enough, though the force of the explosion was tremendous, men who were standing many yards away being knocked down by it, while a huge hole was ploughed in the ground, the Emperor was not killed outright, but both he and his assassin fell to the ground terribly injured. Elinkoff died very soon afterwards, but his Majesty lingered in dreadful agony for several hours. His lower limbs and part of the abdomen were torn and shattered to pieces."—*Littell's Living Age*, **61** [5], 301–306; 1888, from *The Gentleman's Magazine*.

Prof. Watson Smith, F. C. S., F. I. C., has kindly supplied us with a copy of his address "On Kinetite," reprinted from *Jour. Soc. Chem. Ind.* **6**, 2–12, 1887. This substance, which was invented by Messrs. T. Petry, O. Fallenstein, and H. Lisch, of Düren, is prepared by dissolving gun-cotton, or other cellulose nitrate, in the nitro-compound of an aromatic hydrocarbon—for example, nitrobenzene—and then they knead potassium chlorate and nitrate, ammonium nitrate and similar compounds, with the resulting jelly, and finally three per cent of antimony pentasulphide is added to the whole and well incorporated. High power, great stability, and cheapness are claimed for this explosive, and the reports of many excellent chemists are cited in support of these claims. The English Inspectors of Explosives are, however, not yet satisfied as regards its security in use and storage. The address was accompanied with illustrative experiments.

Another explosive, called petrofracteur, is described in the foregoing paper. It is composed of nitrobenzene ten per cent, potassium chlorate sixty-seven per cent, potassium nitrate twenty per cent, and antimony pentasulphide three per cent.

At a recent meeting of the Royal Society of Edinburgh, Professor Tait made some interesting and suggestive remarks on "The Effect of Explosives." The singular fact had been stated that an explosion of dynamite in the Underground Railway in London produced the curious effect that some persons within a certain range had the drum of one ear ruptured while no effect was produced on the drum of the other ear. If he had not been thinking for years about the effect of lightning flashes upon the air he must have set this down to newspaper reporting. The effects of a sudden explosion in the immediate neighborhood of the centre at which the explosion took place, and the effects of the same at a moderate distance, might be perfectly different from one another; and when examination was made of the matter from the physical point of view, it was found that the difference depended on this: that as long as the projectile matter—whether it was the air itself around the explosive, or the materials of the explosive which were driving it from the centre of the explosion—were going at a velocity greater than sound, the effect of their motion was precisely the same sort of thing as is observable in the case of a falling star. It compressed and immensely heated the air immediately in front. So long as it exceeded the velocity of sound there could be no vibrations propagated beyond the limit to which the explosion had extended, and the gases only came, as it were, into contact with a dead stone wall of stationary air outside. The result was that the air was compressed and became self-luminous by the instantaneous compression. So it was with lightning. Up to the point at which the velocity became that of sound there would be an exceedingly intense impulsive pressure, and there was great danger of very considerable damage. The question of how much force was required to rupture the drum of the ear was a question for physiologists. Being asked by Dr. Wallace how it was that for explosive purposes gunpowder required to be inserted into the material to be exploded while dynamite was placed on the top, Professor Tait replied that dynamite exploded with great rapidity, and the consequence was that the gases expanded with exceeding rapidity, whereas gunpowder was burned comparatively slowly and produced the effects

of increased pressure with graduated speed. If the velocity was much greater than that of sound there was percussion, otherwise there was nothing but the propagation of vibration. It was the difference between a wave and a breaker.—*Engineering*, **43**, 577; June 17, 1887.

Smoke will certainly play an important part in the warfare of the future. Last year at Milford Haven, and this year in Langstone Harbor, it was artificially created in large quantities in order to form screens behind which attacking forces might, unobserved, approach within range of forts and batteries. On each occasion rafts laden with combustibles were set on fire and floated into positions from which the wind carried the smoke in a more or less dense cloud in the direction of the defense. On the other hand, ever since the introduction of modern ordnance and rapid rifle fire, it has been felt that the huge volumes of smoke which would be belched forth during a battle of the present day would probably prevent the use of big guns to the best advantage. Smoke, in fact, may, according to circumstances, be either a great assistance or a grave impediment in warfare. The ideal state of things is, of course, one in which the production of smoke shall be controlled, so that either a clear atmosphere or a clouded one may, as need may arise, be created around a battery or ship in action. This ideal has now to some extent been attained. It is found that smoke, as it issues from the muzzle of a heavy gun, can be almost instantaneously precipitated by means of a simple electrical apparatus. The invention is based upon the researches of Prof. Tyndall, Lord Rayleigh, and Prof. Lodge on the action of electricity upon floating dust and vapor, and it should be of considerable military value.—*Boston Herald*, Dec. 18, 1887.

F. Nettlefold has sought to ascertain "The Influence of Nitrate of Soda on Gun-cotton," meaning thereby the effect due to the hygroscopic property of this salt. He made primers of uniform size containing (1) lime in small quantity, as required by the Government, and 30 per cent KNO_3; (2) lime and 30 per cent $NaNO_3$; (3) 30 per cent of $NaNO_3$ only; the variation in lime being made since it had been suggested that lime might, by conversion into nitrate, act as the absorbent. The substances were exposed in damp places for varying periods and the change in weight noticed. The data obtained is given, but in such form that it is difficult to ascertain what conclusion is to be drawn from it.—*Chem. News*, **55**, 241; May 27, 1887.

F. Nettlefold, F. C. S., discusses in the *Chem. News*, 55, 306; 1887, the "Nitration of Cellulose," a subject which assumes greater importance as the production of the lower nitro-celluloses for use in powder and for pyroxylin increases, and which is also of importance in connection with the manufacture of military gun-cotton. It will be readily understood that the thin wall tubes of cotton fibres are readily penetrated by the mixed acids, and consequently the highest state of nitration results. In the case of ligneous tissue the cells have been thickened by matter from the sap and almost blocked up. This thick wall is not so readily penetrated, and so only lower nitro-bodies can be obtained.

Thus with clean cotton, using a mixture of 33.3 per cent nitric acid 1.506 sp. gr., of 94 per cent HNO_3 and 66.7 per cent H_2SO_4, sp. gr. 1.840, a near approach to trinitro-cellulose is attained—a product with a solubility of 7 to 9 per cent, having a proportion of nitrogen 13.94 to 13.86 per cent, against a theoretical proportion of 14.14 per cent N in pure trinitro-cellulose, when 0.85 per cent is deducted for ash.

Since so large a quantity of wood pulp is used in the manufacture of powder, such as the Schultze, it may be interesting to consider the few following experiments to show what definite result arises in nitrating these different bodies, though often described—in the case of wood—as consisting of vasculose, para-cellulose, and fibrose.

Beech wood and fir wood are not easily nitrated, on account of the unstable compounds they form. In the case of a fine sample of white pine flour, named O in commerce, a dark, ochre-colored product was obtained with 41.6 per cent soluble in a mixture of 2 parts absolute ether, 1 part alcohol, 58.4 per cent insoluble in alcohol. The total nitrogen in this was 11.2 per cent. Taking the soluble portion as being dinitro-cellulose, the insoluble remainder would have a proportion of 11.3 per cent nitrogen, or a rather higher state of nitration.

A sample of wood pulp gave also 11.2 per cent N. The resinous matter was extracted by boiling in caustic soda, and the washed residual fibre was nitrated, yielding 11.57 per cent N. This proportion of nitrogen would indicate that the product lay between dinitro-cellulose and the formula given by some authors as $C_{24}H_{37}(NO_2)_9O_{20}$, with 11.9 per cent. It might be conceived at first sight that the insoluble portion consisted of a mixture of trinitro-cellulose and unnitrated fibre, but as a matter of fact woody tissue is not readily brought to this high state of nitration.

The existence of these more complicated nitro-bodies, with four times the formula $C_6H_{10}O_5$, is further seen in the following instance: Cotton was nitrated in weak acid, yielding a product 33.0 per cent soluble in the mixture of ether and alcohol, 63.5 per cent soluble in acetic ether, 3.5 per cent insoluble. Taking the 33 per cent as dinitro-cellulose, containing 11.1 per cent N, the 63.5 per cent would have 10.1 per cent; analysis gave 10 per cent. The formula $C_{24}H_{33}(NO_2)_7O_{20}$ has 10.17 for theory.

$$\text{With}\quad \left.\begin{array}{l} 25 \text{ per cent nitric acid} \\ 75 \text{ `` \quad `` } H_2SO_4 \end{array}\right\} 10.47 \text{ per cent N,}$$

$$\left.\begin{array}{l} 20 \text{ `` \quad `` nitric acid} \\ 80 \text{ `` \quad `` } H_2SO_4 \end{array}\right\} 8.23 \text{ per cent N,}$$

the latter product might be near to the $C_{24}H_{35}(NO_2)_5O_{20}$, with 8.02 per cent N.

With the mixture of strong acids, 33.3 HNO_3, 66.7 H_2SO_4, and various quantities of water, ranging from 10 to 15 per cent, to form collodions, products ranging from 10 to 11.1 per cent nitrogen are obtained; these are all soluble in acetic ether, and are probably homogeneous chemical products.

In the Schultze powder the nitrated wood fibre has 10.44 per cent N, lying between $C_{24}H_{33}(NO_2)_7O_{20}$ and $C_{24}H_{32}(NO_2)_8O_{20}$, or between 11.1 and 10.17 per cent. But in order to obtain this in the case of cotton a dilute acid is required, whereas in the case of wood fibre the strongest has to be taken.

C. Loring Jackson and John F. Wing found that when the symmetrical trichlorbenzene was treated with fuming nitric acid (sp. gr. 1.505) in the cold, trichlordinitrobenzene was formed, and to obtain the trichlormononitrobenzene it was necessary to dilute their acid to 1.46, whereas Beilstein and Kurbatow state that only the trichlormononitrobenzene results from the action of fuming nitric acid in the cold, even when the latter has a sp. gr. of 1.52. To discover the cause of this discrepancy the authors have studied the "action of nitric acid on symmetrical trichlorbenzene," and also on the tribrom compound, and they find the cause to lie in the fact that the nitric acid of specific gravity 1.505–1.51, prepared at the Cambridge laboratory, is much more efficient in its action than the commercial fuming nitric acid used in the laboratories of St. Petersburg (1.52), Berlin and Munich (1.534); and they are inclined to ascribe the high specific gravities of these commercial acids in part to the presence of

lower oxides of nitrogen, while the specific gravity of the Cambridge acid was due probably exclusively to HNO_3, since it was prepared direct from nitre and sulphuric acid without pushing the reaction beyond the formation of the hydrogen potassium sulphate. This explanation was based upon the observation of Kolb* that the specific gravity of nitric acid is raised by the solution of nitrogen tetroxide in it; and although it was not feasible to submit it to direct experimental proof, since commercial fuming nitric acid was not to be had in this country, yet the examination of a nitric acid similar to that used in foreign laboratories makes it exceedingly probable that this explanation is correct. This acid was prepared by distilling common nitric acid twice with an excess of sulphuric acid; it had a decided yellow color, and a specific gravity of 1.535 at 15° (the temperature at which all these determinations were made), but converted tribrombenzene into tribrommononitrobenzene only when acting in the cold, although it gave the dinitro compound when boiled with it. It was therefore less efficient than the Cambridge acid of sp. gr. 1.51, but more so than the foreign acids mentioned above. The analysis of these two acids gave the following results:

	Percent NO_2.	Percent HNO_3.	H_2O by difference.
Acid of 1.535 sp. gr.	5.0	93.38	1.62
" " 1.510 " "	0.5	96.92	3.58

The nitrogen tetroxide was determined in the usual way by treatment of the diluted acid with a standard solution of potassium permanganate. The results are not absolutely accurate, according to Feldhaus,† because of the loss of nitrogen tetroxide in transferring the acid from the weighing or measuring tube to the beaker, but are nearly enough so for this purpose. The nitric acid was determined by neutralization with ammonium hydroxide and weighing the ammonium nitrate dried at 120°. It contained no ammonium nitrite. The estimated amount of nitric acid, corresponding to the nitrogen tetroxide found, has been subtracted, so that the number given represents the percentage of free HNO_3 in the acid.

The number representing the free HNO_3 for the second acid is higher than that given by Kolb as corresponding to this specific gravity (1.51), which is 94 per cent. The difference may be due to the presence of amines in the ammonia used, but the authors did not

* Ann. Chim. Phys. **10**, [4], 137. Kolb's table is given in Watts' Dict. Chem. **6**, 866.

† Zeitschrift für anal. Chemie, **1**, 426.

study this point, since they were not interested in the absolute determination of the HNO_3 in the acid, but only in the relative amounts in these two acids, and these are given accurately by the numbers, since they were obtained under exactly parallel conditions.

These results show that the acid with the higher specific gravity contains the smaller amount of HNO_3, and therefore that the determination of the specific gravity is not a trustworthy way of finding the strength of nitric acid, unless the sample examined is free from the lower oxides of nitrogen.—*Am. Chem. Jour.* 9, 348–351; 1887.

From the *Oil, Paint and Drug Reporter* of Jan. 4, 1888, we learn that during the previous week an explosion occurred in the drug and spice mills of McIlvain Brothers, at Fifteenth and Hamilton Streets, Philadelphia, which destroyed several windows and seriously injured the workman in charge of the mill, who was severely burned about the face, neck, and arms. The cause of the explosion is not known, but is thought to have been due to improper material having been sent to the mill to be ground.

"The Explosion at Amoy" is described by Miss Gordon-Cumming in the *St. James's Gazette*, and from this we learn that the magazine at the time of the explosion contained 40,000 kilos (88,000 lbs.) of gunpowder. As a result of the explosion, fifty soldiers were blown to atoms, several hundred other persons were killed, and a multitude grievously injured. All the buildings on the side of the town where the magazine was were shattered, and as houses fell fire was scattered. A great conflagration speedily ensued, rapidly spreading till it extended over a fourth of the whole area of the town. The island of Ku-long-su, which is the place of residence for foreigners, and which is separated from the island of Amoy by a narrow strait, was rocked as if convulsed by an earthquake, and several houses fell in ruins. The city of Amoy contained a population of upwards of 100,000 Chinamen, and the island of Amoy, which is about ten miles in diameter, contained an estimated population of about 250,000.

From the daily papers of Rochester, N. Y., we learn that a very serious explosion occurred in that city December 21, 1887, by which three men were killed and twenty seriously injured, while three large flour mills were knocked down and then set on fire, besides which the streets were badly torn up; the estimated loss being about $250,000.

Investigation showed that the explosion was caused by the ignition of vapor of naphtha, which found its way in enormous quantities into the sewers, mixed with air, and that this naphtha had escaped from an underground pipe line which was used for conveying the naphtha across the city from the Vacuum Oil Company's Works to the Municipal Gas Works. Some 14,000 to 15,000 gallons of naphtha were pumped on this day from the Vacuum Oil Co's Works, none of which was received at the Municipal Gas Works, so that this amount was involved in the conflagration and explosion. It is supposed that the vapor was ignited by the fire under a boiler in a cellar on Platt Street, but of course there must have been many opportunities for ignition. The coroner's jury found the Vacuum Oil Co. responsible for the disaster, but we learn that both companies have been indicted.

This explosion originated from the same cause as the one which occurred in Pawtucket, R. I., July 19, 1886, a full account of which may be found in the *Providence Journal* of July 19, the damage done in this case being confined to tearing up the roadway, breaking window panes, demolishing some slight structures, and injuring some of the bystanders. It is noted as a curious feature of this explosion that in every case the glass from the windows was thrown into the street instead of into the buildings. We understand that the responsibility for this accident is yet before the courts for decision.

Prof. C. A. Young, of Princeton College, describes a "curious explosion" which occurred there while filling a cylinder with oxygen. The cylinder was a forty-foot one of steel, made to stand a pressure of fifteen atmospheres, and had been used at that pressure for a year or two. At the time of the explosion the pressure was only about ninety pounds. The oxygen was being pumped into the cylinder from the gas holder by an ordinary force pump driven by steam and making about eighty strokes a minute. The lower portion of the cylinder was immersed in water to keep it cool, and the pump piston was lubricated with a heavy mineral oil such as is used in steam engine cylinders. The seat of the lower valve was of hard rubber, and had just been faced off, so that the pump was in exceptionally good order and working very effectively. The connection between the pump and cylinder was by a heavy lead pipe of about a quarter-inch bore and five feet long. Two persons were in attendance; one, the mechanician, stood by the pump watching the pressure

gauge, the other, his assistant, stood by the cylinder. Suddenly a flame, blue or green, and some three or four inches long, made its appearance on the top of the cylinder where the lead pipe was coupled to the stop-cock. The assistant sought to turn the wrench to prevent the loss of gas, but before he could do so the explosion occurred. The cylinder was torn in two about six inches from the bottom, the upper part striking the floor above, and the glazing and plastering of the room was much damaged. The mechanician had his eyebrows singed, and a piece of metal as large as one's hand shot through the brim of his hat; the assistant was thrown nearly twenty feet against the gas holder and was a good deal bruised and shaken, but not seriously injured. Somewhat similar explosions have occurred at Princeton before in charging the oxygen cylinder, but none so severe, and they are said to happen in establishments which deal with gases on a large scale.

The inside of the cylinder, in the explosion above described, was found to be covered with a film of oil which came from the pump cylinder, a little puff of gas and oil spray passing through the valve at each stroke of the piston. Hence Professor Young concludes that the explosion was due to the firing of oil spray, and possibly a little oil vapor, mixed with the oxygen gas, and that the firing was caused by the sudden pressure produced at the lower valve of the pump by each piston stroke.

To prevent these explosions he recommends that soapsuds be used as a lubricant in place of oil.—*Scientific American*, p. 369, June 11, 1887, from *Popular Science News*.

Explosions during the preparation of oxygen have repeatedly occurred in the past. One which happened at Cannes in 1880 attracted considerable attention from the factitious circumstance that it was being prepared for the Empress of Russia. In this case, according to the *Répertoire de Pharmacie*, it was held by M. S. Limousin to be due to particles of incandescent potassium perchlorate being driven over into the rubber tube and generating hydrocarbons, which formed an explosive mixture with the oxygen. In this case potassium chlorate *per se* was being used, and it is not uncommon that when the violent ebullition takes place, sparks are seen rushing through the water of the interposed washing flask. The gas then appears to force its way through the water in such a manner that the central portions do not come in contact with the liquid. Explosions

from accidental admixture of antimony sulphide and combustible matters have not been infrequent.

The *Revue Scientifique*, pp. 262–272, Feb. 26, 1887, contains a very readable article by M. Favier on the "Explosives of the Future," in which, after describing and classifying the explosives now in use and considering their methods of formation and decomposition, he arrives at the conclusion that we must abandon the organic nitrates and nitro-substitution compounds as too sensitive for use, at least for military purposes, and that the explosives of the future will be mechanical mixtures. He gives results with several such mixtures, which appear nearly as powerful as, or more powerful than nitro-glycerine, but no hint whatever is given as to their composition.

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NEW YORK BRANCH, NEW YORK, N. Y.

February 9, 1888.

Lieut.-Commander Leonard Chenery, U. S. N., in the Chair.

The meeting was called to order at 9 P. M. by Captain A. P. Cooke, Vice-President of the New York Branch of the Institute.

Captain Cooke stated, as he had been requested to read a paper on the subject of the Naval Reserve, for the purpose of provoking discussion, it was to be hoped that a full and free expression of opinion might be had, in order to enlighten those interested in the subject. He then called upon Lieut.-Commander Leonard Chenery, the Corresponding Secretary of the Branch, to preside during the reading of the paper.

Lieut.-Commander Chenery, on taking the chair, made the following address:

Gentlemen:—It may not be out of place at the first meeting of any size and importance of the New York Branch of the U. S. Naval Institute to state, very briefly, something concerning the Institute itself.

It was founded in 1873, nearly fifteen years ago, "for the advancement of professional knowledge in the Navy, by affording a medium for the free interchange of serious thought and the debate of important subjects concerning naval science and practice."

The headquarters of the Institute are at Annapolis, at the Naval Academy, but it has branches at the prominent Navy Yards and Naval Stations. Its regular meetings are held at Annapolis, for the transaction of business and for the reading and discussing of papers on professional subjects, but occasional meetings are held at the Branches for papers and discussions. Its membership, composed of Honorary, Life, Regular, and Associate members, is made up of officers of the Navy, Army, Revenue Marine, and persons in civil life "who may be interested in the purposes of the Institute." I am happy to say that it has a large number of the latter class in and around New York and a constantly growing one. The membership, as a whole, numbers now in the neighborhood of 850.

This is a meeting to-night of the New York Branch of the Naval Institute; it is held on this side of the river, rather than at the Navy Yard, for the con-

venience of its members and guests. The paper to be read and discussed is of such popular interest and national importance that we have invited a much larger number of guests than is usual, and we extend to those guests a hearty welcome and invite them to take part in the discussion, criticism, and debate with the same freedom that belongs to the members themselves.

In a subject of such vast magnitude as the one before us this evening there are many interests involved, many points of view, many conflicting ideas as to a practicable plan of operation and the details and specifications for the proper carrying out of the same, and it is thought that the Institute offers a neutral ground, peculiar to itself, where all of these interests may be represented and their claims and plans set forth, and that out of it all there may come good seed that shall be pregnant with golden fruit for the future.

On behalf of the officers of the Institute, I again bid both members and guests a most hearty welcome.

Captain Cooke will now read his paper.

OUR NAVAL RESERVE AND THE NECESSITY FOR ITS ORGANIZATION.

By Captain A. P. Cooke, U. S. N.

The importance of having a Naval Reserve has of late occupied much attention. A bill to create such a force was last winter introduced in Congress by Senator Whitthorne, and bills of a similar purport will be introduced in both houses during the present session of Congress. The matter has been this year, for the first time, mentioned in the annual report of the Secretary of the Navy, and organizations interested in maritime affairs have brought the subject forward for discussion. It is a very large and important subject, involving various and diverse interests; it will bear considerable discussion, and should have all the light possible thrown upon it from different quarters. What other governments have done in this direction has been tabulated by our own, and will doubtless be published in due season. Any law establishing a Naval Reserve should deal only with general terms, giving the President authority to formulate the necessary regulations. Yet a thoroughly feasible and useful scheme must be presented for consideration, with all the details for organizing and managing such a force carefully worked out. In order to accomplish this, all classes interested should have a voice in determining the plan, and what has already been done by others should be carefully considered in connection with our own requirements and limitations.

The Naval Institute, through its Board of Control, has therefore determined to throw the weight of its influence in favor of the establishment of a Naval Reserve, and to open its arena for discussing the usefulness and necessity of such a force, as well as the manner in which it should be organized, drilled, and instructed in order to bring about the best possible results.

Any effective scheme for a Naval Reserve must, besides opening a field for the training of our officers and men, also secure an efficient commercial marine fitted for remunerative competition with other nations on the great ocean highways; at the same time preparing material in men and ships for offensive naval service whenever national exigencies may require it. In pursuing such a plan we simply follow the sagacious example of all other great maritime nations. And it is well to remember that our enormous contributions to their carrying trade are nourishing and cherishing a naval reserve power for those nations which possibly may, at no distant day, be turned against us. To adopt the successful features of the commercial administration of other powers is a wise rule for the conduct of our own. Considering the results obtained by the other great maritime states in a liberal support of their merchant shipping, this country should surely profit by their example. The same consideration extended to our ocean commerce that has been bestowed on our lines of land transportation would give this country the control of the carrying trade of the world, and our lines of steamers would be only the continuation of our great trunk railway lines to foreign markets. Many considerations are involved in restoring this great national industry, which in time past contributed so much to the pride, power and prosperity of our country.

An efficient fighting navy cannot be maintained without a strong, vigorous and trained commercial navy; and it is important to familiarize the outer world with the sight of the American flag, and have other nations think of our country, not as merely the theme of distant rumors, but as a maritime power able to defend its rights in any quarter of the globe. It therefore becomes the bounden duty of the Government to develop and foster the growth of our merchant marine, which was the birth-place of our navy, and must ever be a nursery for the gallant men who are to make our flag respected and feared upon the ocean. The Navy has always a deep and abiding interest in nourishing our commercial marine, for from that source must chiefly be drawn its recruits in time of war. Our past naval

successes were largely won by the endurance, skill, courage, and fidelity of these sailors, and history records their conspicuous services in all the wars in which we have been engaged. The true national importance of a great commercial navy cannot be over-estimated. Such a fleet, created and maintained by private enterprise, although built for peace, will be found our most sure support in time of war. Not only will the ships of this squadron of commerce be invaluable, in many ways, for war purposes, but especially necessary for swelling the ranks of our volunteer navy will be the hardy mariners trained in their service; and the building of these ships will offer an essential training preparatory for war. It is as necessary for our people to be experienced in the building of ships as to be skilled in the manufacture of guns and other warlike implements. Naval power rests primarily on shipbuilding skill, and the necessary opportunity must be afforded for acquiring experience in this art. An efficient naval power cannot be secured without encouraging and protecting the ships and sailors of our country.

By patronizing foreign vessels we aid in the development of the cruising fleets of our possible enemies, instead of giving every advantage to American enterprise, which in return would reward us by maintaining our maritime power. Since it costs our people so many millions of dollars annually in freight money to carry our wares to the markets of the world, why should we not make an effort to expend some of it at least in giving employment to our own people, and by so doing, also render ourselves independent of others? It certainly is sound doctrine that, if money is to be spent, it should be done in giving occupation to our own workmen. And is it not worth the nation's while to encourage by favoring laws its shipping interests, in order to accomplish all this and so much more along with it? There could be no better expenditure of public money than the granting of aid to specially built steamers, both small and great, to be held available for the naval service in case of need; such additions to our merchant marine to be constructed so as to be readily converted into armed cruisers or torpedo boats. If we wish to have swift steamers in order that efficient transports and other vessels may be secured for service in time of war, we must make it an object for owners to build and maintain such craft; otherwise we will have to construct a greater number of steamers for the Navy than is necessary in time of peace. Moreover, the first expense of such vessels would only be a fraction of what they would ultimately

cost the Government; whereas the subsidized craft would only require a small annual amount, and besides being useful in peace, would always be available for war.

Something must be done to restore the American ship to the ocean, or it will soon disappear altogether. It can be saved, however, by adequate payment in return for the great national benefit rendered by those who are willing to put forward their individual earnings and assume the necessary risk. Before ships can be built and sailed, the conditions for their profitable use must exist, and there must be a certainty of their constant employment. When employment fails the industry will languish. To reinstate our shipping interest and renew its activity, the inequalities and disadvantages in competing with foreign ships must be removed or compensated. The Government must surely defend and provide for the commercial and navigating interests of the country, and the property rights of its citizens, both on the sea and on the land. Government protection may take many different forms to favor, restore, and maintain our merchant marine; but without some helpful interference, it stands demonstrated that we cannot resume our carrying trade on the ocean. And it is a fact that without some kind of government protection in the way of favoring laws, this industry has never prospered.

A Naval Reserve involves both ships and men. As in peace we shall maintain only a small regular force of men, so will it be the same, to a great extent, with the ships; we shall never have enough of these in the Navy for all our needs in war. For this reason the able measures now before Congress advocating the establishment of a Naval Reserve, contemplate the building up of our shipping interest. As an auxiliary to the Navy, the merchant marine affords not only a school for the training of seamen, but also a reserve of ships and dockyards which may supplement the resources of the Navy. Although these craft will be exceedingly useful in many ways, the nation should never deceive itself with the idea that it would be safe to put this class of vessels in the line of battle or depend upon them as fighters. The other chief maritime powers have already, by bounties and otherwise, secured the right to use a great number of their merchant steamers to assist their navies. Recognizing, therefore, the certainty that steamers of high speed will be used as naval auxiliaries, we have every reason to be thankful that measures are being taken to secure our having such vessels. When

sea-going steamers are built in this country for commercial purposes, and also when yachts, tugs, and small craft are constructed, the owners should be encouraged by the Government to make them according to such requirements as will render them suitable for naval uses. And this can be done without interfering in any way with their usefulness to their owners. Sufficient inducement must be offered to accomplish this, and all such vessels held available for Government service.

Naval Reserve ships, compensated for accommodating themselves to naval requirements, and enjoying liberal mileage for mail service, or receiving the bounty proposed for distances sailed according to tonnage, should contract to carry a certain number of Naval Reserve men, and to give the Government the power of engaging them on fair terms and at peace prices in case of need. Thus, at moderate cost, the country would secure the nucleus of a fleet of auxiliaries which would be invaluable in war.

In a sea-going squadron of modern fighting ships, each of the units will have to be attended by numerous satellites. The parent ship will require to be furnished with torpedo boats capable of keeping the sea, lookout boats, and a torpedo boat catcher, while the squadron will require a dispatch boat, a store ship, a hospital ship, a magazine ship, colliers, and powerful tugs.

In our coast defense, too, an important feature will probably be armored guard ships heavily armed, each supporting a swarm of lightly armed small craft. It will thus readily be seen that we shall have abundant necessity for auxiliaries, besides using them as commerce destroyers.

It has always been customary for the national Government to keep up a small contingent of regular forces where the art of war is studied and practiced, and where a little nucleus of those familiar with arms may be found for the training and guidance of our citizens when called upon to defend their country. The same causes which lead to a division of labor in the peaceful arts must always make war a distinct science and a distinct trade, and the use of arms must always occupy the entire attention of a separate class. With us this class, in proportion to our wealth and population, has always been an exceedingly small one; and, if it is taken to represent our insurance against national danger, doubts may well exist as to its having increased in proportion to the war risks.

The armed mariner is a product and a necessity of civilization; and as the latter advances, and the art of war becomes more complicated,

the former must devote more time to his specialty, or he can never use effectively the complicated weapons of precision he is now called upon to wield. In the early days of smoothbores and sails, before steam and telegraph were known, it might have been safe enough to defer the moment of preparation to the season of actual hostilities; but our national armaments should now be kept ready and manned. The existence of the trained defender of his country, wholly aside from the question of war, is of benefit to the community; and the maintenance of naval and military establishments, in due proportion to the wealth and population of the state, adds to its prosperity.

The preparation for war, besides developing the mechanical and industrial resources of the country, cultivates also the hardy and essential virtues of courage, discipline, and self-sacrifice; and the ordinary training of men for arms is directed towards producing and nourishing these virtues. Those who are trained to defend their country are fitted to endure hardship, to sacrifice their wills and natural inclinations to a sense of duty. They are required to practice constant restraint and self-denial, and to face pain, sickness, hunger and thirst at the call of duty. Their very lives are not their own, they may neither refuse to give them nor yet waste them, and they must always count them at the disposal of others. What better school could be devised for making good citizens and for cultivating all the nobler qualities of manhood? Surely such a training of both body and mind is not to be despised, and affords a valuable opportunity for cultivating among our people the most elevating virtues.

The vague suspicion that men trained to arms are responsible for war is as groundless as to consider physicians responsible for disease, or clergymen for violations of moral law. The most terrible and destructive invasions have been those not conducted by regular forces. It is not those regularly commissioned who stir up strife, but the spirit of money-making and greed is what chiefly brings it about. The triumphs of commerce, far from being peaceful, have almost invariably been either preceded or followed by the use of arms. The highways of commerce, both by sea and land, have been opened up by fighting. Armed forces are not the cause of war, but they regulate it and reduce it to its mildest terms. Neither are armed men drones in the hive nor a burden of non-producers on the community. Much useful work must be done besides the production of wealth; its protection is no trifling responsibility. Many useful citizens are not by their profession wealth producers, and some

of them not even wealth protectors; yet the trained defender of his country can at least claim to exercise the latter function.

Force is necessary as well as law in the organization of society and government, and a proper force, ready to be called out in case of need, might enable our country to go on for hundreds of years without ever having to strike a blow. A well planned scheme for developing our resources, comprehensive and elastic, giving full scope to the enormous local reserves of the country and utilizing them to the utmost, would be the most effectual guarantee ever devised for perpetual peace.

The old methods upon which we have always relied for defense are now impracticable. We have, however, done very little in the way of providing new ones, although the means lie ready at our hands. The larger and wealthier centres offer defensive material on the spot which we have only to organize. They should possess the necessary facilities for training men in the use of the delicate and complicated machines of modern war. Let us hope the time is not far distant when every one will admit the absurdity of leaving enormous commercial interests, not only without the necessary men trained for their protection, but without the weapons and appliances for their defense. All great areas of commercial activity should have defensive centres of their own, from which the means of defense could be procured without delay. The rapidity of modern war will leave no time adequately to meet attacks concerted by telegraph and delivered simultaneously at points thousands of miles apart.

Our regular navy may be said to form a normal school where teachers are prepared to organize and instruct the great body of our seafaring population upon whom this busy country must rely for the protection of its maritime frontiers, when the hardy toilers of the sea are suddenly called from gathering its fruits to protect their homes and firesides.

Besides the regular forces maintained by the general Government, the States have militia organizations where the duties of a soldier are learned, and where reserves may be secured for our armies in case of war; but none of the States have organizations for instructing sailors as a sea militia, nor has any provision ever been made, either by the States or the nation, for securing trained reserves to recruit the Navy in case of war.

The very excellent scheme for organizing our Naval Reserves which Senator Whitthorne has brought forward, provides for the

enrollment of a Naval Militia as well as the organization of Naval Reserve forces. Heretofore no naval enrollment has been made, and no provision now exists for assigning naval quotas to States in case of war. Under the existing militia laws all persons between the ages of 18 and 45 are to be enrolled, and it is very important that provision should be made for assigning naval quotas to the States when desired. After providing for the general enrollment of a naval militia, Senator Whitthorne proposes to give the States authority to organize such naval commands as may volunteer to join certain branches of the Naval Reserve forces. This puts the Navy on the same footing as the Army, as far as possible, in relation to the militia. Only a few of our States have really efficient National Guards, and probably many of them would not feel disposed to organize Naval Reserve forces. The far-reaching and comprehensive nature of the Whitthorne Naval Reserve bill is shown by its provision to meet this possible contingency. While giving abundant authority to the States for organizing Naval Reserves, it does not depend altogether upon their uncertain action, but, considering the nation responsible for the common defense, makes ample provision for a regular national volunteer Naval Reserve organization under the control of the general Government. Moreover, the general organization, training, and control of the Naval Reserve forces is to be placed in the hands of the Secretary of the Navy, who may detail such regulars as may be deemed necessary for purposes of inspection and training.

The establishment of a Naval Reserve, if entrusted to the States alone, would surely be beset with difficulties. Although there is no lack of good material, yet the absence of a central control would be even more seriously felt in naval than it is in military matters. The liberties and fortunes of the States are entrusted to the National Government, and although great reliance seems to be placed upon the old provincial militia system, the theory of national defense can not proceed altogether on lines of separation or State independence.

In the light of our past history, the importance of a permanent national volunteer organization is apparent. The records give overwhelming evidence in this direction. In all our wars the main reliance of the nation has been on national volunteers. As yet, we have never maintained a national volunteer force in time of peace. There are many reasons, however, why it would be very desirable. Since in our next war the general Government will at once call out a force of United States volunteers equal to the emergency, why wait until then before having such an organization?

Since our standing force is wisely kept within the lowest possible limits, we must always rely upon volunteers when enlargement becomes necessary. Therefore we ought to develop some comprehensive system, so that such an organization may be in practicable shape for augmenting our sea forces when needed. Volunteer naval organizations at the different ports should be encouraged, and all those interested in maritime affairs induced to join. Thus interest would be excited in these organizations and in the craft which would be available for their use, and generally in the work of protecting our coasts and harbors, which they would have to perform in case of war. In some such manner, at no great expense, a system could be established which would not fail to be of the greatest benefit whenever we are involved in war. Once every year, during the most favorable season, operations should be carried on to test the efficiency of the plan and to make the reserves familiar with the weapons and methods to be employed.

The defense of our ports by guns and submarine mines is not sufficient of itself. There must be an active force afloat. The material is partly at hand in the various coasting and harbor craft which are to be found so abundantly along our coasts. These, manned by naval volunteers and armed with quick-firing guns and torpedoes, would make an excellent improvised force. We need, too, an ocean volunteer force, to which the ships, officers, and men of all sea-going traders should be eligible, with depot organizations, consisting of boatmen, fishermen, and all our sea-going population of every class and denomination; thus transferring a glaring weakness into a pillar of strength fit to support the honor of our country. There are few men belonging to any of these classes that could not once a year at least answer to their muster before a government official at the ports they frequent. And most of them would be glad to give a small portion of their time to their country for instruction in its defense—if not all at once, then by instalments during the year, as they had opportunity and could secure off-days from their regular occupations. This is the germ of the idea sought to be accomplished so far as the men are concerned. A registry must be had at every port on sea, river, or lake, where every man familiar with boating and the water, coming up to certain requirements as to age and qualifications, may be induced to register his name and address, and to report himself every year for such brief instruction and service as the Government shall require. The patriotic citizens of our country will need little pecu-

niary compensation as an incentive. The honor of being classed as a Naval Reserve man, and the advantages and instructions derived, will be a great inducement. In case of war, of course they would want credit for their service in the Reserve and expect to enjoy all other benefits accruing therefrom.

The last great warlike uprising of our countrymen convinces us that whenever the patriotism of our people is touched it will be difficult to restrain enlistments. Every portion of our country and every community will be anxious for representation in any cause that appeals to the noblest impulses of our people. To whatever extent we may need fighting men they will be forthcoming, and their alacrity and enthusiasm will be unbounded. Yet it will not do to depend altogether on the unorganized patriotism of our citizens. Without preparation they would not be serviceable, and although they would make reserves in time, the important element of time might be lacking—time for discipline and general training, without which they would be worse than useless. The conditions of war are not now what they were, and the result may be decided in a few brief weeks, victory resting with those who have made the most careful preparations. To trust to hastily organized crews when the emergency arises is to court defeat, for fleets are only consolidated by patient care and skillful forethought. The ships of our future Navy will be very different in type from those of the past, and the crews required to man them different in character. A promiscuous collection of landsmen and untrained seafaring men, hastily placed on board such vessels, would be rather more dangerous than useful.

It is not easy to realize how completely all the conditions of war have been changed within the last generation of men. The enormous increase of the interests to be protected, and of the valuable points to be defended, would alone alter the whole problem. But science has played an even more important part than growth. We cannot now equip a fleet one-half as powerful in relation to the work it would have to do and the foes it would have to meet, as we possessed in our last war. Whatever the future may bring forth, we are confronted by the present and ever growing necessity for adequate and concerted preparation to repel the assaults, direct or indirect, open or covert, which our situation, our wealth, and our prosperity invite.

Some day we must meet an enemy prepared to fight who will not wait for us to get ready,—and what are we going to do about it? We are, of course, rich and strong and prosperous, and full of

confidence in our ability to hold our own against all aggressors, yet we utterly lack preparation. No State, whatever its position or its traditional policy, is always secure against an invasion of its rights. With heavy responsibilities and imperfect guaranties, by neglecting preparation we invite aggression; for we can only assert our rights effectively by showing a capacity to enforce them. In spite of our reserve resources, any of the great nations—and we claim to be the peers of such—might strike us a sharp, sudden blow, inflicting injuries which no belated exertions would avail to repair. It is comforting to dismiss this idea as impracticable; but, although no occupation would be permanent, yet temporary local possession in a critical moment is far from being impossible, and the immense forces of foreign nations and their complete organization, together with the modern facilities of transportation, make such an enterprise more probable, as a sudden movement, than ever before. Why should we be so short-sighted as to put off making any preparation to meet the inevitable, when this is the convenient season? Now, in this time of profound peace, it is our duty, as a nation, to ourselves and our posterity, to prepare for the sure coming of our next war, by establishing an efficient Naval Reserve organized by the general Government. The development of such a force can only be brought about by the reiteration of public opinion on the subject. It is of vital importance that the movement in that direction should be successful, and a comparatively small effort made in this cause now may avoid the necessity for large sacrifices hereafter. It is certainly the duty of the country to look after such a scheme and have it carried into effect. Much may be done by local effort and by the exertions of patriotic individuals. In fact, it is only by such exertion that we can hope to accomplish anything. The Government will never take action in such movements until earnestly and persistently urged by those in a position to command attention. For this reason it is most important to interest all our influential citizens occupied in any way with those who do business on the great waters or who go down to the sea in ships.

If there is any subject on which our people should be agreed, it is the necessity of providing for the common defense. As a matter of fact, however, unless some scare gives rise to alarm, they trouble themselves very little about the matter. Yet, in the early part of the present century, the appearance of a hostile cruiser off some of the towns of our coast was no unusual occurrence; and now, steam and

long range guns have made a repetition of such visits a matter of disagreeable certainty. Under such circumstances it would seem wise to have some scheme for holding possession of our own waters, prepared and understood before the coming of the evil day. Our coasts and shores will be best defended by keeping an enemy away from them. And our ports, besides their submarine mines and attendant artillery, must have floating batteries and movable torpedoes, together with electric lights—the whole arrangement being under one management. Besides, the forces employed should, by exercises and combined operations, have some idea of what they are expected to do and how it is to be accomplished. If we are ever put to the test of war, while in our present chaotic condition of preparation and loose state of co-operation, the trial will be very great, to say the least.

On the declaration of hostilities, all the navy we can raise will be required out on the open sea, and naval volunteers will have to be relied on to man all the movable defenses of our harbors. Our present small navy could spare neither officers nor men for such purposes, even if the craft required were forthcoming. As a nucleus for our floating harbor defense we could use our smaller coasting steamers, tugs, and steam yachts, but we are sadly in need of suitable modern, specially built, harbor defense vessels, as well as gun and torpedo boats.

Why should we not have now an organized body of naval volunteers charged with the defense of our harbors and drilled in the work? Doubtless they would be ready and willing to qualify themselves for the performance of this duty if they had fair opportunities of rendering themselves efficient; but at present, those who must be relied on for such service are totally without the necessary instruction, and the needed tools are unavailable. Even the obsolete material in our possession is not ready, and those who must command these flotillas lack the needful experience. The solution of the problem appears to lie in the creation of a permanent naval reserve and volunteer coast defense corps. There should be sufficient regulars in time of peace to look after the stores and boats, the remainder being volunteers, who would have an annual training. There would be no difficulty in getting those who have been trained in the regular service, as well as yachtsmen and merchantmen interested in the matter. Every harbor should have properly qualified officers responsible for every detail. At present, nobody being

responsible, nobody cares. We must have a well digested plan, worked out and familiar to us, and upon which we have already experimented. The Navy will need its trained reserves even more than the Army. Besides its being easier to secure an effective soldier in our country than an efficient man-of-war's-man, the latter will be drawn chiefly from a smaller portion of the population. The Naval Reserve will come to a great extent from those who dwell on the sea and its tributaries: our fishermen, yachtsmen, the crews of coasters and deep sea craft, as well as the boatmen on our rivers and lakes. All these must be enrolled, their residences and employment known, and they should be connected in some way, however slight, with our regular reserve establishment. Such registration would place a most valuable knowledge of the maritime resources of the country at the disposition of the Government. These people are to a great extent a non-resident and floating class of the population, yet it would require very little to make them offer themselves at convenient localities and seasons for certain brief periods of training.

A Naval Reserve cannot be established without incurring some expense. It costs much to take advantage of all the modern improvements in arms and armament and to be able to use them effectively, but the nation that provides for these things will be likely to succeed. Unfortunately, as yet, we have not furnished our regular forces, or even the Naval Cadets at Annapolis, with modern equipments. It also costs much to make the service popular and efficient—but this is essential. The wages and advantages offered must keep pace with those which the laborer and artisan enjoy.

Our defensive establishments are an insurance against national danger. We pay without a murmur high premiums for insurance on our lives and property, but it seems to be with great reluctance we contribute to this most essential insurance. Its expense will be much greater now than formerly, not only because the capital invested is greater, but because other requirements are greater. Formerly our ships were of wood, our guns inexpensive and small; there were no torpedoes, machine guns, electric lights, or other costly devices; the pay was less and it cost but little for training. Now all this is changed, but we are rich and prosperous enough to endure the change. It is only a question of whether the necessary funds shall be expended carefully and deliberately in these quiet times of peace, or recklessly and extravagantly in the hurried and anxious season of danger. When the country, confronted by immediate peril, is startled

by the revelation of its utter want of preparation, it will then be too late.

Every maritime power except our own has ready for service a reserve, which includes not only sailors, but coast artillery and volunteer torpedo corps; and so thorough is the organization of some of these forces that in the event of war their mobilization would be a question not of weeks but of days. Although the enrollment of our seafaring population should be complete, it is not expedient or necessary to include so large a number in our proposed Reserve. We need, however, a Reserve of officers and men sufficiently large to man all the additional vessels we should require in case of war, both for cruising and for the protection of our harbors; also to fill the waste by sickness and casualties during war.

Suppose, with our present small Navy and limited merchant marine, we should begin with ten thousand men and officers as the necessary number for our Reserve. This would about double our regular force, and they might be formed into ship's-companies at the various localities where our Navy is now represented. Let a ship's-company, or several ship's-companies, forming a division, be organized at the port of New York, for instance. I am sure a fine ship's-company, completely officered, could be recruited there at once from officers and men in civil pursuits who had served their time in the regular Navy. These would take great pride in such an organization, and would sacrifice a great deal to accomplish it. Let them be granted the privilege of using the old frigate Minnesota, now located in the North River, off the city, and employed as a training ship. Unfortunately her equipments are rather ancient, but not more so than in most of our ships, which are fully twenty-five years behind the times. Here they might meet and organize and drill and train, and I feel confident they would take great pride in their work. At some convenient season they might be drafted for a brief cruise afloat. Something of this nature could be readily carried out also at other places. Why not organize into ship's-companies and let the officers look after the details of the work? They will do it willingly, and are only too anxious for the opportunity. In some such way, it strikes me, a Naval Reserve might be instituted without any very great expense, and to the great satisfaction of all concerned. All it needs is the slightest encouragement and countenance from the general Government. There would have to be a headquarters for managing the Reserve, located in the Navy Department at Washington,

with a sufficient staff, drawn partly from the Reserve itself, and with representatives located in each district.

The officers and men of the Reserve, while undergoing drill and instruction at any naval rendezvous or station, or on board of any vessel, should be uniformed and cared for by the Government and receive credit for their service. When called out for service in the Navy the Reserve men should be treated in all respects as our regular continuous-service men, and given equal pay and allowances. The Reserve man might receive a small annual retaining fee, and while on drill should be paid according to his grade in the regular service. Continuous service in the Reserve should be attended with the same privileges and advantages as in the regular service. The advantages to be derived from belonging to the Reserve should be made as attractive as possible and promulgated to all interested. Applicants for enlistment in the Naval Reserve should be in sound health, of good character, and not above, say, thirty-five years of age, unless they had seen previous service in the regular Navy. The enrollment should be for five years, and the Reserves should be required to drill for about two weeks afloat each year and encouraged to do much more ashore. Schools of instruction should be available for the officers, and they might be permitted to enjoy the courses at the War College and Torpedo Station. Reserve officers should be allowed every facility for perfecting themselves in their duty by being attached to ships in commission on certain occasions of general exercises and manœuvres, and at stations where instruction could be received. Vessels ready for active service, and manned with reduced crews, should be detailed for drilling the Reserve, and, at times, the men might be drafted directly for brief periods to the regular cruisers along our coasts. Service in the Reserve should interfere as little as possible with the ordinary occupations of its members, and they should be permitted to do their drilling at the most convenient time for themselves. Many excellent men who would like to join might not be able to have their berths kept open or to get leave from their employers for the full annual term of service required. Such might make up the necessary period at different times. The number of days' annual training should be sufficient to admit of some target firing with small arms, as well as great-gun drill and other exercises. To train a very great number of Reserve men during the same time, at any one station, would be impracticable, because accommodations could not be afforded, to say nothing of rifle ranges and other needed equipments.

The days of receiving ships, I think, are numbered, and our regulars will ultimately be quartered in barracks while ashore. Modern ships will hardly be appropriate for this service, and the old hulks cannot last always. This change will be a great benefit in many ways. We should not, ourselves, like to live on shipboard always, neither do the men. A change of quarters is beneficial to them, and when at sea they will look forward with pleasure to a little tour of barrack life, and from barracks they will likewise enjoy a change to the ship. Properly equipped barracks at the different naval stations would afford excellent quarters and a meeting ground for the Reserves. There they could be organized and drilled conveniently, and doubtless it would be an advantage to both Reserves and Regulars to meet each other. In localities where drill ships could not be furnished, drill batteries and barracks with rifle ranges might be established for the benefit of the Reserves. In training our Naval Reserves, practical efficiency should be the aim and object. They should be instructed only in those things which bear on the practical work they will have to perform. The Reserve is to meet the demands of war, and its people should be trained only to fight, and to take their places at short notice on vessels equipped and ready for such an emergency. The regular naval contingent would generally supply ships with their leading officers and men, while the Reserve would be called upon to furnish the main fighting portion of her complement.

The whole subject of establishing an efficient Reserve for the purpose of furnishing crews to our fleet in war is intimately connected with that of manning the Navy in peace. The force of regular men-of-war's-men now enlisted in the Navy should assist in maintaining a trained and disciplined Reserve. Unfortunately, at present, a very large proportion of our men are foreigners; but this is very wrong, and might be greatly changed if the prospective advantages offered to young American youth who volunteered to select the Navy as a calling were greater. Liberal rates of pay must be offered and higher classes of leading men established; besides, the position of petty officers should be greatly improved. Then they should not have to look forward to an interminable life-long service of active cruising, but be eligible, after a certain period, for shore and harbor service. A man-of-war's-man has nothing to look forward to when serving but his bare pay, and in order to secure a good class of petty officers and re-enlisted men, sufficient prospective advantages should be offered them. Nothing will so bind a sailor to the service

as the sure prospect of being cared for when old and worn out. And nothing will more surely attract a valuable class of men to the Navy than the knowledge that their pensions will, in part at least, be continued to their families. A service pension will have great attractions. After, say, twenty-five years of faithful service, all enlisted men should be permitted to retire on three-quarters pay, and should be liable, if under fifty-five years of age, to be called out for active service in case of emergency. Such men would need no training. No reserves we can ever secure will be equal to men who have passed a term of active service on board ships of war. The whereabouts of all men who have served in the Navy could be known at slight expense, and these alone would afford a most valuable reserve. There is a strong desire on the part of men who have served to be identified in some way with the service, and all those who do not wish to re-enlist should, on discharge, be encouraged to join the Reserve.

We have at present no power of expanding an establishment barely sufficient for peace purposes, into a navy prepared for war. We should, at least, always have the means of sending forth a fleet with alacrity, and in sufficient strength to hold possession of our own waters.

Our Revenue Marine might be recruited from the Navy, forming a trained reserve at all times ready for service. Every enlisted man of good character, after having served a sufficient number of continuous enlistments in the Navy,—say three,—might be eligible, upon recommendation, for the Revenue Marine, as a reward for faithful conduct. And this service, after being regularly attached to the Navy, might be increased and utilized for guarding our coast and instructing the Reserves. By keeping the Revenue Marine thus manned by regulars, they would at all times be available for transfer to fighting ships, when their places could be filled by less trained recruits. In this way we should hold in reserve a strong body of trained seamen, all accustomed to the discipline of a man-of-war and familiar with its requirements.

Let us hope our people may soon be awakened to the necessity of putting forth some of their vast strength in the direction of national defense. From our commanding position we have looked abroad across the seas and seen no danger of aggression, and having no hunger of conquest, we have simply devoted all our energies to internal improvement. But now that we have accomplished so much within our own borders and have accumulated so much to protect,

since the means of communication are multiplying and distance is being annihilated, and we find the world getting smaller and the nations nearer together, let us, like a giant refreshed by long peaceful slumber, set about building up our broken-down hedges and repairing our ruined walls, and with our abundant millions of accumulated wealth let us go forth and make ourselves impregnable.

DISCUSSION.

Mr. J. W. MILLER.*—*Mr. Chairman and Gentlemen*:—When a mere lad—some twenty years ago—it was my good fortune to be under the instruction of the eminent gentleman whose able essay we have heard to-night. I thought then, what I know now, that in dealing with the various professional subjects, whether seamanship, navigation, or gunnery, he invariably approached them from the broadest possible standpoint. It is, therefore, more of a pleasure than a surprise to me to-night to note the zealous and patriotic way in which he has handled the subject of the Naval Reserve, and to find, also, that he has gone into so many details regarding the matter; but I am rather afraid he has knocked the wind out of my sails. However, the subject is such a great one, especially in the light of its relation to the country, to the state, to commerce, the various maritime interests, to yachtsmen, the Life Saving Service, and the Revenue Marine, that it is perhaps well that at least some discussion should be given to the essay. With that end in view, I shall take the liberty of reading a few remarks that I have written, representing the view of an ex-naval officer.

Regarding the Naval Reserve from the point of view of an ex-naval officer, my attention is first drawn to the fact that there is distributed throughout the country a large body of men who have formerly been in the service, and who, collectively, might be made to be of great and immediate value to the Navy. Individually they are scattered so far and wide that any benefit would be neutralized unless they should be enrolled in some systematic manner. These men consist: First, of officers who served during the War; second, of recent graduates of the Naval Academy who, on account of the lack of vacancies in the various grades, have been forced to resign; third, of a small body of men who have served before the mast and who should be enrolled in the Naval Reserve. Upon the second class the Government has already spent money and time and should have its equivalent in return. It is scarcely too much to state that the young men who pass four years at the Naval Academy and then leave the service should be forced to join the Naval Reserve. It is due to the Government and due to them that they should continue to render an equivalent for the education received.

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The enrollment of all the above classes should be on the basis of rank and rating which they had on leaving the service, provided they are physically, mentally, and morally qualified. Ex-naval officers (from the regular service) should also be entitled to the rank of their date or grade, provided that they can pass an examination corresponding to that of their contemporaries in the regular service, and that they could bring to the Naval Reserve a force in men and discipline equal to the command of their date and grade in the regular service. It will thus be seen that an ex-naval officer could not by virtue of his former rank, *per se*, obtain high position, but must add thereto work and brains in forming and systematizing gun's-crews, divisions, ship's companies, naval brigades and squadrons, until the result of his labors raises him from the lower rank in which he left the service through intermediate ranks to the highest obtainable.

To enlist the interest of the persons mentioned above, some inducements similar to those given the militia must be offered. In order to combine the personnel, the coast and lakes should be divided into geographical districts. A gunnery vessel should be stationed at the headquarters of each district; this vessel to be used for port drill only, and to be analogous to the militia "armory." The vessel should be commanded by a regular officer, with the greater part of a small crew composed of "continuous service" men retired; a paymaster to enroll all seafaring men who volunteer, and to keep record of the same; but these seafaring men should not be entitled to join the Naval Reserve until they qualify in the regular gun's-crews, divisions, naval brigades, etc., of the district. Their qualifications to be determined by a Board of Control consisting of a "district captain" and five commissioned officers of Reserve. Each district to be divided into ship's companies of 100 each with their officers. Ship's companies to consist of two divisions; each division to comprise two gun's-crews with their proper officers.

Objections may be raised to dividing the Naval Reserve by districts as outlined above. The rights and laws of States may interfere. In forming a *National* Naval Reserve, the traditions hostile to centralizing armed forces may feel outraged and the scheme may become unpopular. The better policy may be to allow each State to form its own sea militia in the same manner as it does its regiments, the general Government providing, on the request of the Governor, such ships, material and officers for instruction as the State may desire. The advantages of this system would be a praiseworthy rivalry between the commonwealths, a local development of maritime interest on the seaboard and lakes, and above all, at least an enrollment of seafaring men who in case of war would be at once available, and who when called into active service would be credited to the quota of the State from which called. This latter point is important: at the outbreak of the Rebellion no data of this kind existed, and neither the Navy nor the individual States got the credit for sea-going volunteers. The consequence in the past was, as it is in the present, and will be in the future, that the Navy, though regarded with pride, was not close to the hearts of the population.

The Naval Reserve commanded by ex-naval officers and organized by States

will bring the Navy scattered over the globe into more intimate union with the country, the States and the people.

Lieutenant J. C. SOLEY, U. S. N. (Retired).—*Mr. Chairman and Gentlemen:* —It is a very fortunate thing that we are going to discuss a matter here this evening upon which we all agree, and that is the necessity of a Naval Reserve; and in view of the fact that we are all agreed on the necessity of it, it is unnecessary to criticise and condemn it.

What we want to do to-day is to try and unite all our opinions in such a manner as to develop a permanent and feasible organization. The nautical taste of our people is so strong that they will readily go, particularly those in the seaboard States, into any organization which has a naval basis.

We have seen that, apart or outside of the service, the efforts made by gentlemen who are fond of the sea, and who are devoted to aquatic pursuits for their own amusement, have touched the keynote of the necessities of our situation to-day. We want a Naval Reserve; the only question is, how is the best way to obtain it. In the first place this able essay makes it absolutely unnecessary to dilate on the necessity for a Naval Reserve. We all know how much we need it; we all want it, and we are all going to have it, but up to this time we have been in a state of apathy. The whole nation has been in a state of apathy. We have stood still and been willing to see other nations build vessels, thinking we could build ours after war had been declared by some foreign nation. But that has been proved to be practically an impossibility. We have got to build vessels for ourselves and now. We have got to build more vessels, and the more we build the better ones we will build.

I want to-night to propose a method for a plan for a Naval Reserve which I think will be feasible. Our peculiar federal relations make the subject a very delicate one to handle where it comes to a matter of military organization. The European organizations are suited to the nations to which they belong; none of them will suit our peculiar conditions. The federal relations provide for certain contingencies which are unknown amongst foreign nations; their commercial relations are also different from ours.

Now we have had a bill presented in Congress, and the thanks of the service are due to the Senator from Tennessee for the valuable services he has rendered to the country and to the service in presenting his bill. Even if it is only a bill, we have passed the threshold. We have been living in a state of apathy heretofore, and now in the Senate of the United States, and amongst gentlemen who are devoted to yachting and aquatic pursuits, and in the Navy, we see the spirit cropping out all over, everywhere, of a desire to establish a Naval Reserve, and it shows the bond of sympathy between sailors. And we sailors, all of us, have got to take hold and man the deck tackles; we have got to lift the anchor from the sea of apathy and take hold and do our best for the service. We are all going to work for the service; nothing can be done in opposition to one another. The only thing that we have got to do is to work together and develop a suitable plan, and the bill for the Naval Reserve which has been introduced, as I have said, I consider a great boon to the service;

but I do not suppose that the honorable Senator who introduced it considers that it is conclusive in its present form, and I speak with a great deal of hesitation when I say anything that approaches towards a criticism of it, because I am sure that with his experience in the halls of Congress, and particularly during the war, that the Senator from Tennessee has studied the matter of federal relations much more closely than I have. I can only speak from the standpoint of my associations with other men, who belong to militia organizations, who are in business, and whom I am constantly meeting from day to day. Therefore, I am not going to criticise the bill at all, as far as the Naval Reserve is concerned, but I do hope that when it comes to be more carefully studied, some of its provisions may be changed, and the plan that I am going to propose looks towards such a change.

In the third section of the bill it is provided that the officers shall be selected and commissioned by the State authorities, and I agree with it there entirely; but after that it says, "If found qualified by the Board of Naval Officers, they may be commissioned by the President, but the holders of such commissions have no claims upon the United States for pay or compensation." It seems that this is very anomalous, because the officers are commissioned in the first place by the State authorities, and after the State has given sanction to that commission they are to be examined by the naval officers to see if the State ought to give that sanction, and then they are to be commissioned by the President, but after they are commissioned by the President they shall have no claim on the United States for pay or compensation.

In the Whitthorne bill I have found another subject which I approach with the greatest hesitation, but as it has already been spoken of in the essay of the evening, I think it deserves serious consideration. Mention has been made of the necessity for paying a mileage or a subsidy for vessels to be used in the service. Now, so far as foreign nations are concerned, it is very true that in France the mercantile marine, with its maritime inscription, provides for the payment of large subsidies to vessels and for the enrollment of men. But we do not live under the same military organization as that of France, or one similar even to the English service. In the English mercantile marine I grant that they pay large subsidies for mail packets, but it is paid for handling the mail, and not with regard to the availability of the vessel for the service. It is, however, provided there in connection with the admiralty laws that vessels available in case of war may be called for and classed among ships available, and shipowners are requested to send in plans of their ships. If vessels are approved it is because they could easily be used, and they are given preference by the Government, which is informed as to the details of construction, equipment, arrangement of bulkheads, etc. These vessels are only to be called for in case of war and paid for. The shipowners, it is true, have asked extra compensation, but have not been subsidized. The English mercantile marine is the largest in the world. That is as far as they have been able to go.

Now, in reference to building up our mercantile marine: we want to secure a mercantile marine and the establishment of the Naval Reserve, but the building up of our commerce and of our mercantile marine must wait, for our com-

merce depends upon business considerations, and when it is best to do so we will have the commerce under our flag, but it is not best to have it now, and therefore we do not want it. If you have the Naval Reserve wait for commerce, or make it in any way dependent on commerce, you will have no Reserve. The question of our maritime supremacy depends on matters connected with the tariff, and merchants and Congressmen must settle them. Try to connect your Reserve with political measures and you kill it. We cannot go to work to build up the mercantile marine, but we can build up the Naval Reserve. Make it possible for us to build vessels and our merchants will do it, but not by subsidies. In the first place the word is abhorrent to the average American, but allowing a rebate on dutiable articles would give shipbuilding an impetus together with building in private yards. As far as the personnel is concerned, the English system has only been partially successful.

Now there is another point to touch upon, and that is the organization of naval volunteers, which will lead more than anything else to cultivate the sense of sympathy between the people and the service; and naval officers must do a large share and render their best assistance in every way in order that they may strengthen themselves with the people. More attention should be paid to improving our relations with the civil authorities. The civil authorities represent the will of the people; and the establishment of closer relations with these officers will tend to create an interest in this matter which in time will lead to a good result. Now, that I may offer an example I will mention the manœuvres at Newport, which has an admirable harbor, but we want to make the people feel that we are doing something by the fleet exercises, and if the subject of the defense of the principal seaports like New York or Boston should be entered into, the whole question debated in the War College, and then if a fleet could go through their manœuvres here, or in Boston, or Philadelphia, to show from this what can be done in defense of those ports, people will realize that the service is doing something for them. The moment that they realize that we are working actively for them they will turn around and work actively for us.

I do not agree with the point made in the essay, that the law providing for a Naval Reserve should deal only with general terms. The time is past when we shall treat any important measure in general terms. When I first began to think about the matter of the Naval Reserve, my attention was attracted to it by the duties to which I was assigned in Europe, where I had to study particularly the connection between the civil and the military administration of the French marine, and from my studies there, and my training as a naval officer, I felt that the organization of the Naval Reserve must be directed by the central government, and that the whole organization should be under the control of the Secretary of the Navy; but the more I have talked with men in civil life, and men who are interested in these matters, I find that there is a strong desire to belong to the Naval Reserve, but a feeling that the Naval Reserve should be on the same basis as the militia, and the plan which I offer and for which I ask the severest criticism, being perfectly ready to yield any point that does not seem to be desirable, is this: the Government has been for years training officers and men

at Annapolis and in the training squadrons, and of these a large portion have gone into civil life. What better reserve do you want than these very men who have had an education from the Government, with support in their early years whether as cadet or apprentice, and who have now gone into civil life? But these people have been suffered to drift out of sight. Now this is the reserve which is of the first importance and which you can get. The whole Navy should look after this. These men were brought up in our schools, trained in our methods, and are familiar with our discipline; they have been trained and been paid for that training, and those are the men who belong to the Navy. Make these men officers and petty officers; get a certain amount of drill four or five days each year, but get hold of those men. Those are the first reserves; they belong to the Government and it is entitled to use them.

Now, in regard to the second reserve; as I said before, it is a delicate matter to handle because of our peculiar federal relations. We never want to come in opposition to those federal relations, and yet at the same time we want to manage so that there will be a quota of men following the sea, ready for service in time of war. In the last war we didn't have that quota. The States were called upon to furnish their men and they were put in the Army, and after some length of time the Navy got them back, but it was not for some time. In the interval it was difficult to get men in the Navy. Now it only requires volunteers. They will only volunteer in the expectation of some return. Call it the naval militia or naval reserve. This is a matter that requires some serious thought. All I say about it is, that we want to induce the seaport States to form a naval militia, leaving to them the organization, uniform, drill, and other affairs. The Government should assist them by every means in its power, loan them ships, guns and ammunition, and drill officers if they want them. But remember that it is a volunteer organization which will be, if properly handled, a powerful auxiliary to the Navy.

Now, I do not believe in talking about any plan unless it proposes something definite to be done. I have already had some conversation with the Adjutant General of the State of Massachusetts with regard to this plan, and I find that under the law it is perfectly feasible, and although the plan has not been definitely settled upon, it will require some legislation which I do not think there will be any trouble in getting. I wish to quote from the Constitution of the State of Massachusetts:

"CHAP. II, SEC. VII.—The Governor of this commonwealth, for the time being, shall be the commander-in-chief of the army and navy, and of all the military forces of the State by sea and land; and shall have full power by himself, or by any commander, or other officer or officers, from time to time, to train, instruct, exercise, and govern the militia and navy; and for the special safety of the commonwealth to assemble in martial array and put in warlike posture the inhabitants thereof, and to lead and conduct them, and with them to encounter, repel, resist, expel and pursue by force of arms, as well by sea as by land, within or without the limits of this commonwealth, etc., etc."

It is proposed to form a Naval Reserve, or rather a Naval Battalion, and except as regards the Naval Battalion you will not find the plan differs very

much from the one in the essay. It is proposed to form ship's companies at the principal seaports, and though I quote the State of Massachusetts as an example, it is perfectly feasible to take hold of it in the same manner in New York and in Connecticut or any of the seaboard States; but take Massachusetts for example. It is proposed to form one ship's company of one hundred men each, one at Gloucester, one at Marblehead, one at Salem, two at Boston, one at Plymouth, one at Provincetown, and one at New Bedford. They will give about a thousand men for the Naval Battalion. The ship's companies are to be formed into divisions of fifty men each and gun's-crews. The officers are to be obtained in exactly the same manner as the officers of the State militia are obtained. The whole force will report directly to the Adjutant General of the State, because it is of no use to have a double military organization in the State, as it requires too much machinery. But in the Adjutant General's office of the State there is now a complete record of all the able-bodied men liable to military service, all it requires in addition is their occupation. Naturally the seafaring men who volunteer in the Naval Battalion should have an armory at each seaport, and the men instructed fully in the working of rifles and such things as they require on shore. They should ask the general Government to loan them a monitor which may be moved from one port to another at certain seasons during the year, to stay in each station for one or two weeks, in order to allow gun-crews in turn to get proper practice and go on board and get that drill, and then in the summer time it is proposed that the crews should be sent to sea for two or three weeks, and on board ship they should be given exercises at sea-firing at the target and so on.

Lieutenant R. P. Rodgers, U. S. N.—I have read Captain Cooke's capital paper with the greatest interest, and regard his presentation of this important and popular question as most fortunate; and as the creation of a Naval Reserve is being generally considered throughout the country, it is wise to have it fully discussed before the Naval Institute.

I presume all who have given attention to the question under discussion would agree that, from a naval or military point of view, the best personnel for a Naval Reserve would be obtained from a sufficiently large body of well trained men who have already served a prescribed term of years in the regular Navy and have retired from active naval service, either on a small retaining pension, or to other duties nearer home in one of the Government services which should be regarded as a part of the Naval Establishment, viz., the Revenue Marine, the Life-Saving Service, the Light House Service, the Coast Signal Service, the Coast Survey, the Fish Commission. But while this plan may be the most effective and rational for a country mindful of its coast defense and naval prestige, and is in general that of foreign powers such as England, France, Germany, Italy, etc., yet all must concur that under our American system it is impracticable in its entirety. There is no reason, however, why it should not be carried out in a measure, provided the necessary legislation were secured; but even then the Reserve thus secured from our small naval force would be insufficient to meet the demands of war, which entail a large increase

of our fleet, with its vessels of various modern types—armor-clads, cruisers, coast-defense vessels, torpedo boats, etc.

Granted this, the next plan which suggests itself to many as most desirable is a National Naval Reserve, drawn by voluntary enlistment from the mercantile marine and that portion of the population finding employment on the water; controlled, trained and maintained by the national Government. While this plan presents most desirable features, it offers some objections, the chief of which are cost, difficulties of administration, and the insufficiency of the trained force so enrolled to meet alone the demands and needs of the country.

The third plan of enrolling in the coast and lakeboard States, as additional to the force possible under plans 1 and 2, a naval militia from which organized commands may be voluntarily formed after the method of the National Guard, presents features which offer returns in point of numbers, organization, training, and local interest and support, which probably can be obtained in no other way in this country at so small an expenditure.

The subject of creating Naval Reserves in the United States has been discussed by naval officers and others for some years past, and while there have been published many general ideas relating to it, there has not, I believe, been presented any definite plan for the creation of a Reserve of men, officers, and auxiliary naval vessels adapted to the country's needs for the defense of the coasts and the manning of the fleet in time of war, until the present session of Congress, when Mr. Whitthorne introduced his bill for this purpose in the House of Representatives. It is true that Mr. Whitthorne had introduced a similar measure into the Senate during the last session of the last Congress, but that bill, presented near the close of the session, was not nearly so comprehensive and far-reaching as the one which he has now framed, and which is now before the Naval Committees of both houses for discussion.

A careful examination of this bill, to which Captain Cooke has this evening referred, and to which he has, I think I may say, given his assent and support, will show that it affords authority and machinery for the executive branch of the Government to ascertain the nautical or naval population of the country, to prescribe and superintend in general the organization, instruction and training of the personnel of the various branches of the Reserves enrolled, and to secure the war services of the best United States merchant steamers which may be adapted for the purpose of increasing our comparatively small number of cruisers—to prey upon the enemy's commerce, to engage similar cruisers, to accompany the fleet as scouts, despatch and torpedo vessels, etc.

I invite your attention to the several sections of the bill and venture to present to you my views upon them.

Section 1 provides for the enrollment of a Naval Militia (unorganized) in the States and Territories bordering on the sea and lake coasts and navigable rivers; to include all men, between the ages of 18 and 45, engaged in navigation, the construction of ships and crafts, ship-owners and employes, yacht-owners and members of yacht clubs, and all ex-officers and ex-enlisted men of the Navy.

This section should be regarded as of *great* importance, as establishing the

right of the Government to the services of a certain portion of its citizens for duty in the naval establishment, as well as in the army, in the event of war.

Under the existing militia laws all persons between the ages of 18 and 45 shall be enrolled in the militia. But as no naval enrollment has heretofore been made, no provision has ever existed for assigning naval quotas to States in case of war, and during the civil war great difficulty was found in supplying sufficient men to man the fleet. In fact, it was only by arrangement and adjustment between the Navy and War Departments, by which some of those drafted or forming part of the States' quotas could be and were transferred from the Army to the Navy, that men were to be had in sufficient numbers for our ships. This section provides for this deficiency in the future, and under it the Government will be in position to know, with sufficient exactness, the number of men available for naval duty, and to assign the naval quotas for the States.

Letters received at the Navy Department in answer to a circular addressed to the authorities of different States indicate that but little difficulty will be encountered in executing the requirements of this section.

Sections 2 and 3 provide for the organization of certain commands under the State militia laws by voluntary methods, indicate the units of organization, and prescribe that the further organization, equipment, and officering of these shall be subject to regulations established by the President; thus ensuring uniformity throughout the country.

The Naval Reserves of this branch are under this plan to be divided into two bodies or branches:

1. The Naval Reserve Artillery.
2. The Naval Torpedo Corps.

The first to be trained to the use of guns, rifles and other small arms, the handling of boats, target practice afloat and ashore, and be made, as far as practicable, acquainted with man-of-war life and discipline. In time of war this force furnishes the fleet with gunners and men trained to the use of arms of all kinds.

The second, to be trained to the use of torpedoes, torpedo boats, mines, mine-laying, countermining, electric search lights, etc., furnishes the crews of torpedo vessels and boats, and the torpedo complements of other vessels.

The battery of Naval Reserve Artillery is to consist of not less than 80 men. This force would furnish five full gun's-crews of 16 men each, or ten half crews of 8 men each, which is nearly the exact number required to man the battery of six 5-inch B. L. R. and six R. F. G. or machine guns, prescribed for the battery of an auxiliary cruiser.

The crew of the Naval Reserve Torpedo Corps is also placed at 16. This is the number generally assigned torpedo boats abroad, and admits of easy development or assemblage into a mining crew.

While these sections indicate the general features of organization, the details of such are left to the Navy Department, under the President, and would doubtless be arranged by a board appointed by him.

Section 4 resembles the corresponding section in the United States Statutes for calling out the militia. But as the training of the Naval Reserves must differ

from that of the National Guardsman in that the latter receives his instruction and drill at home, in the hours of rest or leisure, while with the Naval Reserve men these must be carried on at points removed from the homes of some, and in batteries, vessels, or boats especially adapted for the purpose. These conditions entail certain expenses for transportation, compensation for labor lost, etc.; and in order that this naval training may be effective, and commensurate with the expenditure made, it is essential that it should be continuous through a period of several days or weeks, and for this reason the second and third conditions under which the President may call out the Naval Reserves (for annual drill and training) are added.

So much of the bill relates to the Reserves organized under State laws.

It may be objected that there are constitutional difficulties in prescribing regulations concerning the organization, instruction, and equipment of the commands of the several States, but in reply I would refer to the present militia laws which have existed in the United States Statutes from the foundation of the Government, and which contain prescriptions much more detailed than any to be found in the Whitthorne bill. I believe Mr. Whitthorne has studied the constitutional aspect of the bill from the strict-construction point of view and feels secure in his position.

Sections 9, 10, 11 provide for the enrollment of another class or branch of Reserves, known under the bill as the Navigating Naval Reserve, which may be regarded as the national contingent of the Naval Reserve forces.

This class will be drawn from the officers, quartermasters, seamen, engineers, firemen and others employed in merchant steamers, and yachtsmen. The officers and men must qualify before a naval board, and are to be voluntarily enrolled in the Navigating Naval Reserve for periods of five years. When so enrolled, they will be obliged to report once each year at a naval rendezvous, and, upon their continued fitness being established, they will receive certain graded compensations or retaining fees.

This body of officers and men would be separately enrolled, and it would have no organization or military coherence beyond the chance association in steamships which might be taken into the public service and in which officers and men might continue to serve. It would be desirable, and the endeavor should be made, to give this class a certain amount of annual training and instruction when the difficulties of doing so can be overcome. But in creating this branch of Reserves the Government would as a rule expect to reap greater advantages from the qualities already acquired in the every-day occupation of its personnel than from the result of the small amount of naval training which it might be possible to give.

The duties of the men of this branch, while of the greatest importance, do not necessitate training to the use of naval weapons. Men and officers in time of war would be detailed to vessels to which a complement of trained gunners or torpedoists were also assigned, and thus complete the ship's company.

It is, however, much to be desired that the officers of the Navigating Reserve should associate themselves with the local organizations at their home ports and embrace every opportunity for securing the benefits of its instruction and

drill, and thereby add to their seamanlike qualities the habit of commanding trained men.

These sections also authorize the temporary voluntary enrollment of a steam yacht, or yachts, which may be adapted for certain services as auxiliary naval vessels to take part in the naval manœuvres of the fleet, or in other naval drills for the purpose of instructing their personnel in the use of naval weapons and the art of naval warfare. The advantages of this clause I believe will be apparent to many of the yachtsmen of the country who have shown so much interest and who have taken so prominent a part in the Reserve movement.

There yet remains a most important clause in this section which authorizes (although it does not command) the enrollment of the personnel of the Life Saving Service, Light House Tender Service, Coast Signal Service, and the Revenue Marine in the Naval Reserves.

The men of these services (the Coast Survey and Fish Commission are already manned by men from the Navy) form the natural First Naval Reserve. They are already under Government pay; they are trained to the water and to the habits of discipline, and should the Executive desire to adjust the question between the Navy and Treasury Department, they could under this act not only be enrolled in the Naval Reserves, but be efficiently trained to naval warfare at but small additional expense to the Government. The advantages of this most reasonable proposition cannot be overestimated in considering this question.

Sections 5, 6, 7, and 8 provide the means of securing the services of those United States merchant steamers found to fulfil certain conditions for war purposes, and encourage the building of faster and safer steamers especially adapted for service as cruisers in time of war. It is proposed under these sections to give a mileage compensation based on tonnage, speed, and distance steamed annually, to any steamer found by a Naval Board to fulfil the Navy Department's requirements for auxiliary cruisers and capable of maintaining a speed of 14 knots or more per hour for 24 hours. The maximum compensation, 30 cents per net ton per 1000 miles steamed, is to be awarded only to those steamers capable of maintaining a speed of 18 knots, while for those whose speeds range from 18 knots down to 14 the compensation is to be graded by a suitable board. The speed condition is not so essential for Lake steamers, because the fastest United States steamer will surely be the fastest of any on the Lakes. Probably the highest speed there does not at present exceed 13 knots. With our present mercantile fleet it is believed that there are not more than 30 steamers which can fill the conditions of these sections. There are also a few steam yachts which fill the requirements, but these would receive no mileage compensation under the act. The steamers receiving compensation will be held subject to the Government's order in time of war or emergency, and must carry a crew which include a certain number of American citizens.

Having pointed out the prominent features of this plan, let us see what results may be fairly expected of it. The object of creating a Naval Reserve is to provide in time of peace for the demands of war for a great increase of the

enlisted men of the Navy, a much smaller increase of officers, and for additional vessels which may be especially adapted for naval service as auxiliary cruisers, torpedo and despatch vessels, etc., etc. For the latter we must depend upon our mercantile fleet; as it improves, so will our additional cruisers improve in character and number.

For the supply of officers we must also look to the mercantile marine, other governmental marine services (other than the Navy), ex-officers of the Navy (of whom there are probably some 300 to 400 in different parts of the country), yachtsmen, and others interested in naval matters. There would probably be little difficulty in officering the increased fleet, so far as numbers are concerned, but there would be much greater difficulty in getting a sufficient supply of *trained* men.

The Whitthorne plan furnishes two methods of supply: first, from the organized commands of Naval Militia, and second from the Navigating Reserve.

Considering the first source of supply, it is estimated that the strength of the unorganized naval militia would be in the rough about 300,000. Applying to this the highest percentage of organized militia (National Guards) to unorganized militia in any State, 5 per cent, we may fairly assume that in time some 15,000 men might be organized into the commands of the Naval Reserves of the States on coast and lake-board.

Considering the second source of supply, the Navigating Reserve, it is stated in official reports that there were, in 1886, engaged in United States vessels of the foreign, coasting and lake trade some 25,000 American citizens. At the same time the number of British subjects employed in British vessels was 162,000. Now, the authorized strength of the British Naval Reserve, which resembles in principal features those of our Navigating Naval Reserve, is 30,000 enlisted men and 920 officers, but in numbers actually enrolled it has never exceeded 17,500 men and 325 officers. This is about 11 per cent of the available force from which to draw. Granting that similar results should attend the organization of a similar force in this country, which is perhaps doubtful, we should have enrolled about 2800 officers and men, of which but a proportion would be efficient, as the total number drawn from includes all classes employed on board ship.

From the Life Saving, Light House Tender, and Coast Signal Services, and from the Revenue Marine, the Navigating, or National, Reserve might draw some 3300 excellent officers and men capable of most efficient service after some instruction and training.

Summary of estimates of strength of Naval Reserves under the Whitthorne plan:

Organized Naval Reserve under States	about	15,000
Navigating Naval Reserve	about	2,800
do. from Life Saving, etc., services and from Revenue Marine	about	3,300
Total	about	21,100

This force of some 20,000 Reserves would wonderfully increase our naval strength, and, supposing ourselves to be possessed of a suitable fleet, would permit us to mobilize it and to take the sea upon short notice to defend our coasts and great cities (for the defense of these to be secure must be a naval defense), and to attack the enemy's commerce upon the outbreak of war.

And how is this force composed? As the summary I have given shows, of about 3300 men and officers from Government marine services, which should be regarded as connected with and forming part of the naval establishment—men already disciplined, already maintained by the Government, and who with little difficulty could be trained to use of arms; of about 2800 men and officers drawn from the yachtsmen and the deep-water mercantile marine, whose services are secured to the Government by a yearly retainer, and from whose number the Navy would chiefly expect to recruit its seamen, quartermasters, engineers, and firemen, and a number of officers of the highest type. This Navigating Reserve, or National Reserve, thus gives us a possible 6000 valuable men (supposing the services under the Treasury to be enrolled), only a portion, perhaps but a small portion, of which would be trained to the use of arms.

The remaining 15,000, of the Naval Reserve Artillery and Naval Reserve Torpedo Corps, are to be organized under the States, and instructed and trained in vessels, boats, or batteries, and under instructors supplied by the general Government. These bodies of men will have the advantages of organization, regular instruction and training under their own officers, who in active service would continue to command them. They will receive the support and encouragement of their local or home interest, and would be especially available from their local knowledge for service in coast and harbor defense vessels, torpedo boats, etc., at their home ports, as well as for the manning of auxiliary cruisers and for filling out the nucleus of trained men-of-wars-men in vessels of the regular fleet.

I do not believe that in any other manner can so large a number of trained men be at present secured to *our* proposed Naval Reserves at so small an expenditure, and I think that the definite plan which Mr. Whitthorne has introduced deserves the support of all interested in the creation of a Naval Reserve, and that it furnishes the authority and foundation upon which a most useful and efficient institution may be built by those whose duty it will be to shape its organization and regulations.

Lieutenant S. A. Staunton.—*Mr. Chairman and Gentlemen*:—In discussing Captain Cooke's excellent paper, I am naturally led to speak of the legislative measure introduced to the present Congress by Mr. Whitthorne, of Tennessee. In this bill the general features of a comprehensive scheme to organize a Naval Reserve are outlined, while a wide scope of judgment and all details are left to the Executive. The wisdom of this large executive discretion will not, I am sure, be questioned; the idea of a Naval Reserve, although old enough in theory, is quite new in its application in the United States, and it is to be expected that any organization of the kind must be moulded and changed by actual experience before it fully meets the needs that demand its creation.

I am glad that Captain Cooke advocates this bill; and I think his objections to state organizations for Naval Reserve purposes may be somewhat modified by fuller explanation and argument. These objections are held by a number of naval officers who dislike anything like state control and who maintain that efficiency can be obtained only by national control. We cannot as yet be dogmatic on this point, but we have a right to reason from analogy. The regiments of national guards are recognized as a valuable army reserve, and there is no good reason why batteries of reserve artillery and crews of reserve torpedo men, organized by the states, should not be equally valuable as a naval reserve. No questions of tactics or mobilization make the latter scheme more impracticable than the former. A regiment of national guards, when called out by the President and mobilized for war service, will be transported to any point where its strength is needed—the same with a battery of artillery or a torpedo crew. The latter will not probably be removed to a greater distance from the homes of its members than the former. In fact, nearly all of the torpedo crews and many of the batteries would fight upon and defend the ground familiar to them from boyhood. It is expected that the full measure of advantage, possible to be realized under any circumstances from neighborly association, home defense, and everything that is included in local *esprit de corps*, would be obtained in these state naval reserve commands.

The bill has received much thought and study from Mr. Whitthorne and from the naval officers to whom he has applied for facts and professional opinion. Its provisions keep carefully within constitutional limitations and follow closely those precedents which are most applicable.

It is in line with the militia laws, giving only slight additional powers to the President, which the character of training and drills renders advisable. Among many endorsements and favorable notices from the press the bill meets some opposition; it has been violently assailed by the Boston *Herald*, which calls it "a gigantic subsidy scheme," and "roughly estimates" the cost to the country of mileage compensation at $50,000,000 per annum.

A naval board of inspection has during the past five years been making reports upon merchant vessels visiting the port of New York, and a similar board has existed at San Francisco. The reports of these boards indicate only 26 steamships (and they include all except perhaps two or three Atlantic coasters which do not touch at New York)—20 in the Atlantic and 6 in the Pacific—that meet the speed requirement of this bill; of these 15 have a sea speed for 24 hours of 14 knots, 1 of 14¼, 3 of 14½, 5 of 15, 1 of 16½, and 1 of 17. The majority have the lowest rate of speed to which Mr. Whitthorne's bill grants any compensation whatever, and only two have over 15 knots. Not one could receive the maximum compensation, and all would require much fitting and alteration to prepare them for service. It is not speed alone, but other requirements as well, that determine the amount given; and these requirements, in the language of the bill, "may be modified from time to time," *i. e.* as the demands of naval construction vary with the progress of naval warfare.

It is fair then, and probably results in more than they would actually receive,

to allot to these 26 vessels the average compensation provided by the bill, and to call this average one half the maximum for each class, *i. e.* 15 cents per net ton per 1000 miles for vessels in the foreign trade, and 10 cents per net ton per 1000 miles for those in the coasting trade, since the compensation may vary between nothing and this maximum. The actual distances made in one year by 17 of these vessels are known. Estimating the remainder on the basis of those known, and computing the average compensation as above, we have a round sum of $300,000 per annum as the compensation paid to 26 vessels. This differs materially from the fifty millions of the Boston *Herald.*

The mileage compensation is not a subsidy, either in terms or intention. It is a retaining fee for future service, obtained by building ships to meet the demands of war. It creates no monopoly—the essential feature of a subsidy—but is open to competition. It is so much money expended for naval efficiency and the common defense. Whatever effect it may have in stimulating ship-building and American commerce is a move in the same direction and to the same end.

The same paper asserts that the bill authorizes the states to "create navies, with all their pomp and ceremony." This is as much in error as the financial statement. What the bill *does* authorize is that the states may raise men to whom the United States supplies arms, equipments and vessels for training, instruction and drill. The vessels will always be under the command of regular naval officers, and the government property always under their responsible care.

Until recently the sole idea of a Naval Reserve has been that formed by the enrollment of seafaring men—the best part of the American merchant service—who were to be trained in the use of arms and were to constitute our needed strength; the same class of men, a certain number of whom are proposed by Mr. Whitthorne as the Navigating Naval Reserve. There is a good deal of valuable material here, and it would perhaps be easy enough to enroll a considerable number; but the practical difficulties of training these men have not been taken seriously into account.

Fifty years ago, when a gun was a piece of cast iron with a hole in it, fired by a match and throwing a solid shot, little special training was necessary to make of a merchant sailor a man-of-warsman. Seamanship was all essential, and disciplined courage was worth more than skill in gunnery when actions were decided by boarding. It is no disparagement to former achievements to assert that what succeeded then would probably fail now. Complicated weapons need special training, thorough and long continued.

The American deep-sea sailor is not available for this training. He makes long voyages of uncertain duration; his returns to his domicile are irregular and unreliable. A body of such men, enrolled in one of our ports, could never be brought together at any one time for purposes of drill. At the best a majority of them could be obtained in squads of 2, 5, or 10 at a time; necessitating the permanent maintenance of a drill-ship or barracks and staff—an expensive measure—and failing totally to obtain those advantages that spring from the coherence and association of an organized body. England, with her magnifi-

cent body of English seamen, has tried this scheme, has used every effort to make it successful, and with results so much inferior to what was hoped, that they offer no encouragement to similar attempts in America.

The Whitthorne bill proposes a division of labor. It will enroll the best seamen, pay them an annual fee, and when they are needed, put them in stations where they can best use their professional knowledge. With each man the Government makes an individual contract. It does not attempt to organize them, but drills them whenever it can do so.

The other people, the state organizations, are men that can be found at any time, and that can be drilled a few weeks in each year, paying them enough to make it an object for them to obey the call. These will be taught as much as possible, and will fight the guns; the others will sail the ship. It is not an ideal arrangement, but we have not ideal powers, and we must do as well as we can. I think it may be confidently said that Mr. Whitthorne has indicated fair possibilities and pointed out a probable solution of a difficult problem.

It is perhaps appropriate to this discussion to sketch a plan of organization which has been suggested to carry out the provisions of the Whitthorne bill; a plan which has received no official endorsement, but which has been produced as the result of a pretty thorough examination of the subject by several officers.

The only prescription in the bill as to the details of its execution is that which puts the minimum strength of the units of organization at not less than 4 officers and 80 petty officers and men for the battery of Naval Reserve artillery, and not less than 1 officer and 16 petty officers and men for the torpedo crew. These numbers are not taken at random, but are based upon the following considerations. The crew of a 5-inch or 6-inch B. L. R. is 8 men, and that of a R. F. G. or H. R. C. is 4 men. The battery assigned to an auxiliary cruiser of the first class will be six 5-inch or 6-inch B. L. R. and six R. F. G. or H. R. C. To man these will require six crews of 8 men each, 48 men, and six crews of 4 men each, 24 men; a total of 72 men—leaving of the battery 8 men to fill the vacancies which occur in action, to work below in the magazines, or to act as riflemen in protected stations. It is expected that such an auxiliary cruiser, when taken into the service, will keep her force of engineers and firemen and quartermasters, already enrolled in the Navigating Naval Reserve. She will be commanded and officered by officers of the Navigating Naval Reserve and Regular Navy. She will be supposed to have her gun platforms fitted and her battery in store. It will only be necessary to put her armament on board and order to her a battery of reserve artillery to make her ready for service. Clerks, writers, certain artisans and servants will be supplied by voluntary enlistment while fitting out, as is now the case in the regular navy. Of these classes of men, from whom no military training is required, there is always a supply.

This strength, enough men and officers to man the batteries, principal and secondary, of a first-class auxiliary cruiser on a war footing, has therefore been taken as the unit of organization and administration. If less than 8 men are required to work a B. L. R. of the calibre employed—this will depend upon its mounting and the protection afforded by its shield—the force in reserve, which

may be employed as riflemen or at light machine guns, will be proportionately increased; but it is safe at present to allow for this number to fight the guns with which the auxiliary cruisers will probably be armed. Eighty men gives us five full gun's-crews (crew and relief) or ten half crews, or twenty R. F. G. or H. R. C. crews. It is a convenient number for subdivision; and for assignment to cruisers of the second class, to gunboats and armed transports and despatch vessels, it would be so subdivided. The unit of subdivision—tactical but not administrative—would be the full crew of 16 men, containing 4 petty officers of different ratings, at least 2 of whom should be instructed in armorer's duties, the care and preservation of weapons. This crew would never be broken up in service; it would be the smallest detail of Naval Reserve artillery made to any vessel. Such a crew, for example, with an ensign or junior lieutenant in command, would be assigned to a despatch vessel armed with two to four rapid-fire guns, or to a gunboat armed with one gun of large calibre.

The battery will be commanded by a lieutenant, with a junior lieutenant and two ensigns as assistants. When the battery is embarked as a whole, all its officers will accompany it; when subdivided, the lieutenant will command the larger portion and the junior lieutenant the smaller one; if broken up into more than two details, an ensign will have a separate command. Many of these batteries will be needed to man ships of the regular navy in the event of war. The permanent establishment will never be sufficient to supply crews for all national ships—battle ships, cruisers, and coast defense vessels. The regularly trained force of seamen and gunners will be detailed in due proportion to all of these classes; probably it will also be found advisable to send a limited number of them on board the principal auxiliary cruisers in order to aid by their knowledge and skill the efficiency of that service. All the vacancies thus made in the complements of regular ships will be filled from the reserve artillery. These duties—to reinforce the regular navy and to man the batteries of the auxiliary navy—it is confidently expected this artillery reserve will faithfully and efficiently perform. Its principal details will be in the auxiliary cruisers and harbor defense ships; its officers while embarked will be marine artillerists only, and not eligible to command nor to navigation duty, unless they have qualified under the examinations held for candidates for the Navigating Naval Reserve. When so qualified they would be eligible for any naval duty, and all reserve officers would be encouraged and aided to so qualify. Many joining the organizations in the large maritime cities would be ready to do so at once.

Should it be deemed advisable to make the batteries larger, it would be done by adding integral gun's-crews of 16 men each—*i. e.* making the strength 96, 112, or 128, with a corresponding increase in the number of commissioned officers, first by adding one junior lieutenant, and after that by adding ensigns. The gun's-crews might then be so organized as to provide bodies of young and unmarried men for cruiser service, leaving the older men to supply the coast and harbor defense ships. I do not suggest such an increase as desirable, but merely to show the flexibility of the bill. It is probable that the strength discussed will be large enough and that increase will not be found necessary.

The strength of a torpedo crew is fixed at 16 men; this is the number required, according to European experience, for the crew of an ordinary torpedo boat with two discharging tubes, and includes firemen and seamen, all trained to torpedo warfare, and the seamen trained to the use of small arms and machine guns. The submarine mining crews have been allotted the same number of men. Four such crews—64 men and 5 officers (a lieutenant would be added to command the whole)—make a submarine mining company of sufficient strength to manipulate the fixed defenses of a port with only one channel of entrance. This is the force allowed in England, and is considered as the minimum. The bill permits the crews, if too small, to be increased at executive discretion.

There is no lack of testimony to the value of local knowledge and habit in submarine mining; all foreign experience bears evidence in its favor, and all foreign progress in this branch of warfare possesses the feature of enlisting and training a permanent local personnel. Knowledge of the tides, of the bottom, of shifting sands and floods in rivers, is all-important. Yachtsmen and pilots, fishermen and boatmen, men from local steamers and harbor tugs, with a sprinkling of locomotive engineers, mechanics and electricians, are to be the backbone of our future Volunteer Torpedo and Submarine Service. As much as possible we shall take into it men of acquired skill in kindred pursuits and of quick resource and unfailing nerve. The crack locomotive engineer who can endure the nervous strain of running his engine 50 miles an hour, will not fail to stand by his post when his boat is steered into an enemy's fleet.

The bill provides that the organization, uniform, equipment, etc., shall be the same in all the states and territories. This is essential, and gives to the force, when called into the service of the United States for war or training, a national character. At the request of state authorities, officers and petty officers of the navy may be detailed to act as inspectors, instructors and assistant instructors of the reserve forces. This insures a uniform system of instruction and drill, and further increases their national character and unity.

An estimate has been made in the report of the Fortifications Board, appointed under the act of Congress of March 3, 1885, of the number of mines, electric lights, and torpedo boats with which our coast should be supplied as a second line of defense. The number of mines is about 5000, of electric lights 200, and of torpedo boats 150. Allotting a crew to each torpedo boat, and a sufficient number of crews to work the mine fields and electric light apparatus, gives us about 300 crews or 4800 men that should be organized and trained in this specialty of warfare.

If engaged in war we should commission all our ships, old and new—everything that could carry a gun—and all the auxiliary cruisers; and would add to our fleet with our best energies. All complements would be increased, and we should need at least three times our present enlisted force (which, including boys under training, is 8250) or 25,000 men, an increase of 16,750. If, as indicated in Lieutenant Rodgers' remarks, 6000 of these could be obtained from the Navigating Naval Reserve and the Government services of a nautical character, we should still have to look to the Naval Reserve artillery for 10,750, which, with 4800 torpedo men, would make necessary over 15,000 men

in the state organizations to supply our demands. With the required batteries and crews to fill vacancies and keep up our naval strength in a war of any duration, these figures would be increased. Lieutenant Rodgers has placed the strength of our naval militia at 300,000; an organized strength of 6 per cent would therefore produce about the force that we need.

Should the bill become a law, the interest that has been felt and expressed throughout the country in the creation of a Naval Reserve can at once find a channel of action. Yachtsmen, gentlemen of leisure, members of shipping firms, ex-naval officers and others, can obtain commissions from the governors of their respective states and raise batteries or crews. When organized and properly authenticated by the state authorities to the Secretary of the Navy, rifles, ammunition, and machine guns will be supplied to these commands; also naval commissioned and petty officers in due proportion to instruct in their use.

Setting up, calisthenics and gymnastics, the manual of the piece, sword and bayonet exercise, target firing, the school of the company, and the drill of machine guns, can be given quite as well to the Naval Reserve as to the National Guard; and in many places the same facilities—*e. g.* firing ranges—can be used. The compass will be taught, and the log and lead line—all the bits of nautical education that the men can understand and that the circumstances favor. The commissioned naval officer will instruct the reserve officers in an appropriately higher scale of effort, and will encourage and aid them to apply for United States commissions. Should a drill ship be moored in the vicinity, the battery will be taken on board for exercise as often as practicable. All this will be only preliminary nursing for the period of drill—the real work of the year—when the battery will regularly enter the Government service and receive systematic and thorough naval training.

The Naval Reserve artillery may be further organized into battalions, to contain four batteries and be commanded by a lieutenant commander; and regiments of two, three, or four battalions commanded by a commander. Two or more regiments in the same state may be brigaded and commanded by an officer of higher rank. The battalion organization would be of practical value for instruction in field drills, but the regiments and brigades would serve only for parades and reviews. The superior officers would have to be carefully selected from seamen eligible to naval command, as otherwise there would be no place for them on board ship. No staff organization would be necessary, as, whether at annual drill or taken in for war service, the reserves would form a part of the navy and be administered as such.

The Naval Reserve torpedo corps will include two district organizations, viz. the mobile force, or the crews destined to man torpedo boats, and the submarine force, intended solely for defensive mining. The training of these two forces will be quite distinct and their duties will not be interchangeable. In both classes individuals will be instructed and drilled as much as possible in the special duties which they are to perform. The demands of the service are of so high a character that they are best realized in this manner.

A considerable outlay in material and stations will be required for this train-

ing: boats for the mobile force and mining outfits for the submarine crews, but this is precisely the supply of war material demanded for the defense of our coasts.

The officers of the mobile force must all be nautical men, since they are to command cruising boats. No such qualification is of necessity demanded from the officers of the mining force, since they will not serve afloat.

Four crews of the mobile force may form a squadron, commanded by a lieutenant; two, three, or four squadrons a flotilla, commanded by a lieutenant commander; and two or more flotillas a division, commanded by a commander.

Four crews of the submarine force may form a company, a lieutenant commanding; two, three, or four companies, a battalion, a lieutenant commander commanding; and two or more battalions, a division, a commander commanding. A company will usually be assigned to the defense of one point, and no port will require a larger force than a battalion.

The scheme is capable of results and is worth a trial. Its success, on the lines laid down, must depend upon the attitude of the people, their appreciation of our defenseless condition, and their desire to remedy it; and the same is true of any other scheme which contemplates dependence upon naval volunteers. Mere details, about which we may all differ, should not stand in the way of any one's support of the bill. It must not be forgotten that it embodies a principle higher than all details, that of the "common defense and general welfare," and this should silence opposition and strengthen its friends.

Mr. J. FREDERIC TAMS.*—*Mr. Chairman and Gentlemen:*—The interests of the ex-naval officer and of the mercantile marine seem to be so well represented here that my remarks will be confined to a yachtsman's standpoint, and some of them, having been based on an advance copy of Captain Cooke's paper, and alterations having been made in the same since its receipt, do not now apply.

That the necessity of a Naval Reserve in this country has impressed itself on all classes who have given the subject any consideration seems to be an accomplished fact. The aim of all those who are working in a disinterested way for the establishment of a Naval Reserve is to provide the Government with material, in men and ships, fitted to a greater or less extent for the purpose, which it can, in time of need, make use of to fill up the skeleton or framework now furnished by the regular Navy.

Captain Cooke in his paper ably sets this forth, and the suggested plan of the general details of organization, etc., as stated by him are most excellent and practical.

He and many others, however, seem to have lost sight of the fact that a bill, H. R. 1847, is now before Congress, having been introduced in the House of Representatives January 4th inst. by Hon. W. C. Whitthorne. It has received its second reading and has been referred to the Committee on Naval Affairs, and is now in their hands for action. And in view of this fact it would seem that the time has come when the energies of those interested in the subject should be directed towards securing the form best adapted to the needs and

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peculiarities of this country, and consequently most likely to secure the best possible results, rather than in continuing the effort towards influencing public opinion.

Captain Cooke in the opening paragraph of his paper says: "A thoroughly feasible and useful scheme must be presented for consideration, with all the details for organizing and managing such a force carefully worked out." This would seem to be the natural corollary to the proposition contained in the preceding sentence in his paper, that "any law establishing a Naval Reserve should deal only with general terms, leaving the formulation of the necessary regulations to carry them into effect, to the proper authorities," the alternative appearing to be that the formulation of the details should appear in the bill. This latter would be almost an impossibility, or, to the extent to which it would be possible, would prove cumbersome and probably defeat its own ends. It is my opinion that it would be wise to leave as much as possible as regards details of organization to a board of well qualified naval officers, who would doubtless consult with representatives of the various classes interested. Captain Cooke goes on to point out that in order to obtain a feasible scheme, "*all* classes interested should have a voice in determining the plan, and what has already been done by others should be carefully considered in connection with our own requirements and limitations." The following ideas are therefore presented from a member of the yachtsman class.

Owing to the very nature of the element in which the Navy operates, material, whether men or appliances, must be specially adapted and prepared for the requirements, or it becomes an obstacle instead of an aid. The living material must have a liking for the field on which it is to perform, and must have acquired a greater or less familiarity with its characteristics and requirements, and must have received more or less training to enable it to make use of experience acquired, just as the inert material must be specially adapted in shape, construction, etc., to be of use in its way.

The material can be made to go towards the regular trained naval officer or specially constructed appliance but a short distance, and therefore the Navy must go to the material. In other words, it must be taken as it is and as much made of it as possible. Many naval officers do not grasp this fact, and forgetting the long years of drudgery through which they went and the continuous training which they are undergoing to attain and retain their present position, which is their life and occupation, and also losing sight of the fact that the material aforesaid is daily occupied in the battle of life and cannot be taken away from it except voluntarily and then at a definite loss to be expressed in dollars and cents, they either underestimate their own acquirements or overrate the abilities or expect too much of the material. On the other hand, few laymen, or rather few who have not been down to the sea in ships, can realize the difficulties or understand the requirements of the case. Between the two, the poor volunteer, anxious to be of service, willing to make many sacrifices, instead of having the way for him strewn with roses, finds thorns and briars.

This view of the case would apply also to other classes of a Naval Reserve not formed exclusively from ex-naval officers.

If the services of yachtsmen would be of any value at all to the Government it could only be in one way, and that is as officers of some sort or another; and in this connection an extract from a letter from Admiral Gherardi, embodying his views on this point, will be of interest: "An available body of men, it seems to me, outside of the fishing and coasting fleets, are our amateur sailors, the gentlemen of the yacht clubs, who would form a body of intelligent and efficient officers. Their voluntary enrollment as a naval reserve, with the exemptions and rules similar to those accorded to the militia of the several States, would prove a service of the greatest maritime strength to the Government in case of war. Their proficiency in seamanship and general nautical knowledge would render their instruction by the officers of the Navy, in the many duties on board an armed vessel, an easy and agreeable task. This once accomplished, their value would be particularly felt in organizing a naval force from the blue jackets, unfortunately of nearly every nationality but our own, that find occupation in American bottoms."

To this class pecuniary inducements could not be offered, and not only would have no attraction, but if offered would have the contrary effect. The inducements should be in the nature of position, honorable consideration, promotion, and a right to fly, under proper restrictions, an ensign indicative of the United States Naval Reserve, instead of the burgee proposed in the Whitthorne bill. The ensign would prove a most potent factor, and would have a beneficial effect and lend dignity to the classes authorized to display it, as has been found to be the case in England, whose blue ensign is always found displayed on the ocean steamship or yacht whose captain has conformed to the regulations in the Naval Reserve entitling him to display it.

It is essential that the whole scheme should be, not of an honorary but of an essentially utilitarian character, in order to obtain the dignity and value necessary to insure its success. That the yachtsmen enrolled in a Naval Reserve should form a distinct and separate class, and be fitted to serve in positions of authority. That the inducements and rewards should be worthy and valuable, but not of a pecuniary nature, and that the representations of all sections of the yachting public should be considered.

Perhaps an intelligent and careful consideration of the bill now before Congress by all classes, and a presentation of the ideas resulting therefrom to the committee in charge of the bill, would lead to some practical result. With neither the time nor the desire on this occasion to go into the matter from the yachtsman's standpoint, attention is called only to the following:

First, As indicated at the beginning of this paper, the bill either goes too far or not far enough. In many respects Senate Bill S. 3320, introduced in the last Congress by Senator Whitthorne also, is not open to this criticism in that it is more general.

Second, The divisions mentioned do not seem to be definite enough, nor do they apparently recognize the separate classes into which all men likely to be enrolled would seem to resolve themselves naturally. To us they are as follows:

1. A suitable division for officers and men who have served in the Navy.

2. The mercantile marine: *a.* Officers,
   b. Men.

3. Fishermen, Life Saving, etc.: *a.* Offshore,
   b. Alongshore,
   c. Life Saving Service.

4. Yachtsmen, or Volunteers, as it might better be called, to include all who would volunteer and qualify under the stated standard:
   a. Owners of yachts and members of yacht clubs.
   b. The officers and men employed on yachts.

In the case of volunteers their effectiveness would rather seem to increase with age up to a certain point, and the higher limit in the Whitthorne bill might with advantage be extended.

The true yachtsman's interest in the scheme for a Naval Reserve is a disinterested one. His time, his person, and, on the part of those who own yachts, in addition, his vessel, will be found in time of need at the service of the Government. All he asks is that he may be given a part in the scheme where his capabilities can be made use of to advantage, and in return receive proper recognition therefor.

Mr. PARK BENJAMIN.*—*Mr. Chairman*:—That part of the discussion which has been naturally of the greatest interest to me is that which has dealt with the position of the ex-naval officer and his relations to a Naval Reserve.

I would like to go into a little bit of history in regard to a reserve attempted to be created some sixteen years ago. I allude to it because in Mr. Soley's very able paper he lays so much stress upon the necessity of bringing in gentlemen who have been educated at the expense of the Government. I have seen it stated—I do not know how true it is—that the average cost of educating each cadet who graduates from the Naval School runs well up into the thousands. In some cases it has been estimated above $15,000.

If that is the case, there are many ex-naval officers who have cost the Government a large sum for their education; and while I do not deem the Government has any legal right to demand their services, yet it undoubtedly has a very strong moral right to do so.

In the year 1873 a small collection of ex-naval officers, whose names I do not now mention, gathered here in New York, and with the sanction of the then Secretary of the Navy formulated a Reserve Corps scheme which proposed that all graduates of the Naval School and ex-naval officers who had served in the service in time of war, and who had honorably left the service, should be enrolled by the Secretary of the Navy as a Reserve Corps; that their names should appear in the Naval Register; that they should be given a nominal rank, and the grades of seniority which they would have held had they remained in the service. They were to do nothing in time of peace, but as soon as war was declared, by that act *ipso facto* they were drawn immediately into the service, subject to orders.

It always seemed to me whatever merit lay in that scheme rested in the uses

* Formerly Ensign, U.S. Navy. Resigned, 1869.

to which these gentlemen were to be put. We had a small Navy then, and all the chance of a much smaller one. The idea was, in case of war, these gentlemen being educated in the discipline and conduct of the Navy, should be ordered at once to those duties for which their civilian experience best fitted them, that is, to equipment and recruiting work, to arsenals, gun factories and, in brief, to all those stations in which more or less practical business knowledge is needed. If they were wanted on active duty, then of course they performed the avocations of their grade. The main object was thus to free the entire active personnel of the Navy for service in the field.

I was informed at that time that that measure had gone so far that a bill was drafted and had received the approval of the Secretary of the Navy, and all necessary preliminaries were arranged for its introduction in Congress with a strong backing, when for some reason it was suggested that the provisions of the bill be published, and a brief synopsis was published—I think in the *Army and Navy Journal.* The reception which was accorded to it by the service was so intensely antagonistic that the whole thing was dropped almost instantly. While individually I did not see a single naval officer who did not seem to approve of it, yet collectively there seemed to be a great many objections to it.

I must dissent entirely from the suggestion of my very good friend and classmate, Miller, in which he favors ex-naval officers, or any one else, organizing battalions or companies after the fashion of volunteer officers of the late war. Not that that is not a very excellent and commendable service, but I do not think a man who happens to have the capacity to get together a company or a large following necessarily possesses the qualifications which are required of an officer. I think, also, any clause which would limit the period of office-holding to a definite length of time would be found rather an obstacle than otherwise. I am speaking now from the general tone of expression and opinion I have heard on this subject for upwards of sixteen years; I do not think ex-officers would agree to it. I think that they would refuse to join under a five years' tenure of office, or under any limited tenure. There are not many of them, nor can it be expected that all would enroll themselves. But it seems to me that their value is such that there would be little sacrifice in giving them permanent office and their original seniority. Just as the last speaker said, the inducements offered must be especially of a sentimental nature. There is no man who has ever been in the service who does not feel the strongest attachment for it — an attachment far stronger than the alumnus of a college feels for his alma mater. Unless something of that kind, something of that feeling can be encouraged, I do not think much success will be obtained in drawing ex-officers together. I doubt greatly whether they will go in under such an organization as that of the militia.

I think we lose sight of the great difference between the training of naval officers and that of a graduate of West Point. When the latter goes back into civil life he may easily keep alive the military feeling. He can go into a militia regiment, but the naval officer cannot have recourse to any similar naval organization. If, however, a naval officer as soon as graduated, or at any time

after that, had a right to enter into the Reserve Corps, no matter what his occupation might be afterwards, his connection with the Reserve Corps would keep him in touch with the service, so that if called back into actual naval work he would be in a position of utility. It seems to me whatever Reserve bill becomes a law there should be some provision for holding the former officers of the Navy in some such relation. Of course there are great difficulties in the way, and they become greater in putting ex-naval officers into positions merely on the basis of seniority. That is undoubtedly true. My friend and classmate, Mr. Miller, could probably go back into the service and none could assume the duties of a naval officer better than he could; but, on the other hand, there are a great many men who have gone out whose course of life has been entirely different, who would probably be rejected as totally unfit for naval life. I think that is the great difficulty in putting back ex-naval officers on the basis of seniority.

I wish to apologize for referring to this limited view of a great subject, but I simply wanted to speak on that point of which I knew the most.

Captain JAMES PARKER.*—*Mr. Chairman*:—Having been for about forty-two years connected with naval matters, first as an officer of the Navy, and, since my resignation in 1866, very intimately connected with the mercantile marine; having a large acquaintance with almost all the persons who own vessels, or who are interested in vessels, in this country, I think I can throw some little light upon this subject.

There is an old statement—something of a "chestnut" I fear—an old receipt "How to cook a hare," and that begins, as I remember, by the statement "First catch your hare." We have been cooking the hare this evening exclusively. I propose to suggest some way to catch it. All these details that have been talked of, it seems to me, would be inappropriate in any bill. Mr. Whitthorne brought that bill to a committee of which I have the honor to be one, and he explained to us that he received it from the Navy Department. I have heard again its provisions most forcibly advocated by that officer of the Navy Department from whom Mr. Whitthorne said he had received it, in a letter (a communication) which has been read here.

Now, I believe in taking our Government as we find it. I believe, therefore, in the effort to enlist the States in this subject; and I think, to that end, the provisions of the Whitthorne bill which are based upon our present militia laws are very desirable. I can see no reason why there should not be those local organizations for naval purposes, for the uses to which such organizations could very well be put to in time of actual war. I can see many reasons why such organizations should be encouraged, and why the naval militia law should be as much a part of the system of the country as the present military militia law, and quite as useful. But we must all remember that, in so far as the militia of this country has any connection whatever with the General Government, that connection only becomes felt when it is taken into the service of the General Government, and becomes a part of its army. It retains, in the case of the State

* Formerly Lieut.-Comdr., U. S. Navy. Resigned, 1366.

regiments, their organizations; its officers are appointed in the first place by the State. When they are mustered into the service of the United States they then become military officers of the United States, as much so as though they had passed their whole lives in the regular service; their rank, their relation to the rest of the military affairs of the United States is fixed by the general law of the United States, and not by the militia laws at all. Now, that is what we want for a Naval Reserve. All the regulations which determine the character of the militia when it has gone into the army of the United States are those which pertain to the army of the United States. The regulations of war immediately apply; all the other regulations that belong to the army of the United States at once belong to this volunteer force, for it becomes an integral part of the army of the United States for the time being. It does not interfere with the regular army; the officers of the militia forces do not go into the regular army and interfere with the register of its officers; and I do not think any scheme should be adopted for this Naval Reserve that would accomplish that result.

Now, what should a Naval Reserve consist of? We want a Naval Reserve to supply the navy of the United States in time of war precisely as the military organizations supplement the army of the United States. We want something from which we can at once inject ships and men into the navy of the United States, and to that extent augment it. Now the question is, How are we to get these? Our citizens own the ships. Men must volunteer into the Naval Reserve so that they can be taken from this body of volunteers when wanted. You can't organize ship's crews on shore. You have got to put those men on board the ships and organize them there as to crews, etc., and then you have got to get ships to put them on board of. Now the question for us to determine is, How are we to get the men and ships? We want ships for all sorts of purposes. In the first place auxiliary cruisers, vessels that can fly across the ocean, inflicting the same injuries upon an enemy's commerce that the Alabama and a few others of the Confederate cruisers exerted upon ours; enough to almost destroy it.

Three or four ships, as my naval friends and those who are familiar with the history of that time know, were sufficient almost to drive our flag from the ocean; to give it a blow from which the merchant service has never recovered. I do not say that was the sole cause of its disintegration and its almost entire destruction, but I do say that those three or four ships—cruisers, vessels that never fought, but always ran from an enemy that could fight—thus attacking the enemy in his most vital part, were the principal cause. That is what we want; there must be some inducement held out. At the beginning of the late war the Government of the United States never seized a ship, but paid for them at prices far beyond their value. Talk about the patriotism of people! When the time comes for them to put their hands in Uncle Sam's pocket they all take a pretty big handful out every time. We found that was so in time of war, and we will find it so in time of war again; and so, when we organize our naval reserve of ships, we should know the terms upon which we can obtain them, based not upon any such uncertain basis as mileage, but upon the actual

value of the ship, by payment of a certain sum per annum for that ship; whether she lies at the dock or goes to sea. Whether she engages in coastwise or foreign trade should not be considered. Is she suitable for naval purposes, should be the only test. We all want to see a bill that looks like an effort to revive the merchant service; but, anxious as I am to see our flag once more occupy its position on the oceans of the world, I do not think this country will ever consent to bring the flag back upon any terms that have the suspicion of the subsidy about it, nor do I want to see the Naval Reserve hazarded by any attempt to connect it with any such scheme to revive shipping on any such basis. Let the two measures be divorced.

Now, how are we to get men? I want to see some inducement held out to them to volunteer into the Naval Reserve, so that, in time of need, we may say "Come," and have them bound to obey. Let us go to our yachting friends. Upon what terms will you agree that the Government may have your services? What scheme should be incorporated in the bill so far as yachtsmen are concerned? We want the organization of gun's-crews and all that, and other measures which are to be found in Mr. Whitthorne's bill. The world at large doesn't understand that talk; by the organization of gun's-crews it doesn't understand anything; but when we say to my friend Mr. Stewart, who is a lawyer and a most excellent one, and who has a yacht—I don't think he has a steam one, but I hope he will have one—"We want your steam yacht in time of war to use as a torpedo boat," and then he should say "You can have her upon such and such terms," we have something that the world can understand. I mention him because he sits before me, and I know how anxious and interested he is on the subject. It would be an insult to offer to pay him money; he doesn't need it and he don't want it; but take the average Jack Tar, who has got to live, and you have got to pay him, and he must be paid in time of peace, as an inducement to give his services to the Government in time of war. I think a scheme that can be offered that will accomplish these simple purposes will provide for the greatest difficulty, which is "to get the hare." Having gotten it, our experience to-night shows that there will be no difficulty whatever in finding receipts for cooking the hare in the best possible manner.

Mr. W. A. W. Stewart.—*Mr. Chairman and Gentlemen*:—I wish to acknowledge my allegiance to the proposition made by Captain Cooke, that the law, if any is passed, authorizing a Naval Reserve, should be embodied in general terms. I mean by that, in general terms kindred to the necessities of the situation. Whatever concessions may properly be made in the bill in order to establish the Naval Reserve, to achieve the best practical results, are considerations which cannot be foreseen definitely, and for that reason I am in favor of framing the bill in very general terms, in order to avoid going from one extreme to the other, and so as to be able to meet any actual exigencies that may arise.

I want to say one word from a yachting point of view. As Captain Parker has stated, I am a zealous yachtsman: I am too zealous a yachtsman to own a steam yacht. I know a few of my friends in the club who do most of their yachting on the water; I will say a word for them. They believe they can be of some service

to the Naval Reserve. Some of them own steam yachts, and I am told by the naval authorities some of these yachts could be made useful in time of war; and those yachtsmen I speak for would be very glad to put their yachts at the service of their country, to submit them to annual inspection and to reasonable regulations, to preserve them always in time of peace in such a condition as will make them fit for naval auxiliary purposes, and in time of war to put them absolutely at the service of the Government. What do they ask in return for this? No possible compensation in money; they ask only some suitable indication of the truth of the fact that they have put their vessels to that extent at the service of their country. It is suggested that a suitable indication of that truth would be an ensign which they might fly.

There are a few yachtsmen who own vessels and they believe, presumptuous as they may be, that they may be of service. I am aware of the changes in vessels; I am aware of the abolishment of sailing men-of-war. I suppose it will be admitted that sailing ships, even for the purpose of aiding our steam men-of-war, form an essential element, and I believe our sailing yachts are useful as encouraging and fostering American sailors, and I believe yachtsmen—and I mean those who are really practical yachtsmen—may be made some use of. They do not want to be understood as regarding themselves as of the slightest use to-day in a Naval Reserve. They are absolutely unfamiliar with the points of war; they are utterly unacquainted with the discipline of the Navy or in the method of handling guns, but they are men of zeal and intelligence, and they are more or less familiar with the sea and have been more or less accustomed to the command of small vessels and small crews. What do they want? They want that you, gentlemen of the Navy, will make some use of their zeal and their undoubted familiarity with the sea, whatever it may be. Train, educate, and make use of the utility of these enthusiastic yachtsmen. They do not want any rewards from the Government. They wish for neither money nor any other dignity than the right to fly some suitable ensign indicative of the truth that they are thus putting themselves in a position to be of service to their country when called upon. One thing more—I am sorry to find myself making a speech—we are quite satisfied, so far as any uniform or rank or exchange of courtesies is concerned, to put ourselves in your hands, and we will wait until we have achieved the work. I suppose that, while yachtsmen may be credited with a good deal of zeal, it is not equal to that of those gentlemen who have made it the serious business of their lives to serve their country, and who are alone entitled to all the dignity of the service. We appreciate that the rewards, great as they may be, and ought to be for such sacrifices, are chiefly sentimental, and they ought not to be cheapened by the creation of an artificial taste for the imitation naval officer.

The following remarks, received in writing from some of those who were invited to discuss the paper but were unable to attend the meeting, were not read owing to the lateness of the hour. By direction of the Board of Control, they are here appended as a part of the discussion:

Captain A. R. Yates, U. S. N.—*Mr. Chairman and Gentlemen*:—The able paper of Captain Cooke upon the Naval Reserve, now under discussion by the Institute, is one worthy of the thoughtful attention of every citizen of our country, and particularly of every officer in both branches of the military service. That steps are taken to create a Naval Reserve is a very satisfactory sign of the increasing interest throughout the country in the welfare of the Navy as well as in that of the mercantile marine.

The fact that the Navy has no adequate source from which to draw its seamen in time of war is so well known and has been so often stated in papers and in discussions, that it is unnecessary to do more than allude to this sad condition.

The requirements for an able seaman in the Navy of the present day are so different from those of one before the Rebellion, that were the commercial marine now in the flourishing condition it was then, its seamen would be lacking in some of the most important qualifications now necessary to the efficient performance of the duties of a man-of-warsman. In fact, outside of the Engineer's Department, the men now to be obtained from this source would not be nearly as valuable to the Navy as those derived from that source before the Civil War. The experience and training obtained by men in the sailing ships then developed qualities that fitted them for service in a man-of-war, and when steam was an auxiliary and ordnance was comparatively simple, as in those days, a short period of training converted the merchant sailor into the active and efficient naval seaman. Since steam has taken the place of sails as the principal motive power on the ocean, and the man-of-war of to-day is a mass of machinery by which not only the ship is impelled but the ordnance handled, the majority of the crews of the steam merchant vessels—deck hands as they are technically called—possess in no higher degree the qualities of an efficient naval seaman than did the afterguard-sweepers in the old sailing frigates those of topmen. From the quartermasters and the few seamen the merchant steamers carry we hope to draw a small force at least, but unless the commercial marine becomes of a respectable size the number will be but a small part of the force required in the event of a war with one of the maritime powers.

The qualities necessary for a first-class seaman in the steam merchantman of to-day are the knowledge how to steer, heave the lead, and handle the small sails she carries—qualities necessary in a man-of-war undoubtedly, but the experience thus obtained is not calculated to produce that hardihood, fertility of resource and self-reliance that the daily contact with danger in handling a sailing ship in all weathers generated in the courageous sailor of thirty or forty years ago. It is true that the life in a modern cruiser is not conducive to the production of these qualities, but this is in a measure compensated for by that training resulting from the drills, routine, and discipline.

From our fisheries, off shore and in shore, we would probably obtain our most efficient crews for the modern man-of-war. In them the hardy qualities of the seaman are developed, which, though obtained in fore and aft vessels, are such important adjuncts to a man-of-warsman that with a few weeks training they would become tolerably efficient as naval seamen.

Although yachts with few exceptions cruise but in summer and in moderate

weather, and draw their crews from our merchant service, mostly from the coasters, yet there is a fair discipline maintained in most of them, and this with the training obtained in the sailing yachts, particularly in the racers, are of value to the naval seaman.

The experience of a sea life, no matter in what capacity, is not to be neglected in the Naval Reserve man. The future wars will be short, and but a few days will elapse after the declaration of war before a fleet of ironclads might be off one of our important seaports. Should we possess the necessary vessels to attack the force, they should be manned by those who, in addition to being able to manipulate the batteries, are familiar with the sea and accustomed to be upon it, although the vessels in which they might serve should be only coast or harbor defense ships.

Could anything be more humiliating than that an attack should fail or a vessel be captured owing to the seasickness of the seamen? This may appear an absurdity, still not so very improbable. In my own experience in the sloop of war Cyane in 1863, while beating out of the harbor of San Francisco, nearly two thirds of the crew, who were one year's men and had made the passage from New York to Panama in a steamer, and from Panama to San Francisco in the Lancaster, were so seasick as to be of little use, and consequently the task of working the ship through the Gates was not unattended with risk. This is an exceptional case, as the Cyane was a short ship and the sea was choppy; still the circumstance impresses one with the necessity for some sea life for those who are to man the coast or harbor defense ships, and I have mentioned this circumstance as showing the need of the Naval Reserve man being a seaman, at least so far as familiarity with the sea is concerned. Were this not a requisite, landsmen to man our armored battle ships might be drilled in barracks or forts, since these vessels have no masts nor sails to handle. No kind of drilling with guns on shore will entirely take the place of that in a seaway. Even with the old 8-inch and 9-inch smoothbore guns, the crew that would work and dismount a gun in a remarkably short time found that it had considerable to learn before it could do the same in a moderate seaway without injury to themselves, gun, and ship.

In anything I have said about the men in the merchant service of to-day I do not wish to be understood as belittling their importance in case of a war, for this I fully recognize. I wish simply to show the great necessity for training the Naval Reserves, and further to bring to the minds of those interested in this subject the fact that the crews of the merchant steamships are not now, as formerly, nine tenths seamen, but that one fourth is a liberal estimate for the number of seamen—or those who know how to "reef, hand, and steer"—to be found in their crews at the present day. With a sea life all are acquainted, and this experience is not to be ignored for reasons I have given. To give the Naval Reserves any training with guns at sea at the present time, with so few vessels in the Navy, appears to be impracticable, but it is hoped the future will remove the obstacles. In the following sketch of a plan for training the Naval Reserves a temporary provision is made for this object, but it is only an expedient.

While comparatively easy to state what qualities are necessary to make an efficient Naval Reserve man, it is not by any means so easy to formulate a plan to obtain them that will accord with the means we have and the temper of the people. In a discussion of the paper of Captain Cooke, the details of a plan for the purpose mentioned cannot, owing to want of space and time, be given; but a general idea of one can be sketched with the hope of presenting an idea or two to assist those who may be called upon to devise a well digested system of a Naval Reserve force, and with this view I suggest the following:

In our principal seaports let there be moored men-of-war condemned for active service. At the present time we have a number of wooden cruisers that, housed over and sheathed similar to the Vermont and New Hampshire, would last for years, or at any rate until other cruisers are condemned for active cruising and can take their places. On these vessels have three or four officers, as the number of available officers in the service will allow, and a few petty officers and seamen taken from those who have seen a certain amount of faithful service in the Navy. For this purpose those who for slight physical defects are unfit for active service in a cruiser could be given employment. The men for the Naval Reserve force, the number to be decided upon by the Department, should be drawn from the seafaring class, sailors on the lakes and boatmen of all descriptions on the adjacent bays and rivers. These should be enrolled at the nearest naval station, and required to spend at least one month a year for the first two years, afterwards two weeks a year, on one of the Reserve training ships: these periods to be employed in such a course of training as may be decided upon. They should receive while so employed the pay and ration of a seaman in the Navy, and should be given on first entrance to the ship two suits of uniform and their bedding, afterwards furnishing these articles themselves, and in addition to the above inducements they should receive a small sum per month so long as enrolled and conforming to the regulations that may be made by the Department governing the Naval Reserves. The vessels should be provided with a modern gun of each class that it is practicable to mount on them, and with the requisite number of small arms, torpedo gear, etc., that may be necessary for the purpose of instruction.

These Reserve training ships could be adapted for the purpose without much expense. The Constitution at Portsmouth is, with few alterations, available now for this work. The Hartford, Kearsarge, and other vessels of historical note will soon be suitable for this service only. The repairing of the Hartford for an active cruiser, simply out of deference to sentiment, does not appear to me sound judgment. The same sum of money asked for this purpose would fit up all the Reserve training ships needed, and those vessels like the Hartford which have become historical would be retained in a service worthy of their record and age.

From the men under training on these ships could be taken the force to test the torpedo and submarine system of the defense of the port or of the adjacent coast. If to each ship a small gunboat carrying an 8-inch or larger modern gun could be attached, as well as a torpedo boat, the training of the Reserves would be the more thorough. In the absence of such accessories, vessels from

the North Atlantic Squadron, and others specially detailed by the Department, could be directed to take out the Reserves that might be on the ships for an experience of a week or two at sea. This would give a portion at least of the Reserves some training with guns at sea, and so far render them of great value in sudden emergencies.

Any officer of the merchant service, or graduate of the Naval Academy, or owner or master of a yacht, who can pass a required examination, to be practical in its character, and can furnish adequate testimonials as to conduct, character, and ability, should be eligible to the position of an officer in the Naval Reserves. The rank should be determined by the examination, service, and age of the applicant, but should not be higher than that of lieutenant-commander. As inducements to applicants, a member of the Reserve should be permitted to fly a distinctive flag on any vessel he may command, to wear the uniform of his grade when he pleases off duty, and in the event of a war, to be called into active service and paid according to his relative rank in the Navy. Other inducements, such as pay while under instruction, or a small sum per month, as may be deemed advisable, should be offered to obtain the enrollment of officers of the mercantile marine who stand highest in their profession. The officers of the Reserve should be given the facilities of the Government yards and stations for obtaining the knowledge necessary to the performance of their duties, and the same should be given also to those desiring to present themselves for examination as officers. For this purpose an officer or officers should be stationed at the several yards and stations to instruct applicants and officers of the Reserve. The officers of the Reserve should be required to present themselves once a year for instruction at the station at which enrolled, that they may keep pace with the improvements in naval warfare. They should also be called upon to perform such duties with the crews of the Reserve training ships in the line of instruction as may add to the efficiency of both.

Our Navy, as stated in the paper under discussion, will not in times of peace be large; and if not in peace, since to build a man-of-war now requires years where it required months a half century ago, we may say it will never be large. A force of 50 vessels afloat, or 75 or 100 in all, including all classes, is a liberal estimate of the number we are to have in a future as far distant as we can look. To man these vessels with a trained body of seamen equal to any in the world should be our first object, and the number of this regular force should not be less than 12,000. To obtain and retain these men, inducements additional to those already afforded must be offered, such as laws for retirements, interest on deposits (embodied in the report of the Chief of Bureau of Equipment), the pay of the boatswain-mates, quartermasters, and other petty officers of the seamen class made equal to that of those of the other classes in the Navy, the privilege of serving after a certain length of sea service in the training ships with increased pay as instructors and the like.

The present system of training naval apprentices is working well, and with a few modifications will in the future give us a class of seamen for the regular force equal to any in the world; but as this system is not under discussion I refrain from further mention of it.

The plan I have sketched is different from Captain Cooke's scheme for the formation of ship's companies. I think his plan would be an excellent one if it were possible to collect the men composing the companies, but when one thinks of the wanderings of seamen, this seems almost an impossibility. In the plan I have mentioned officers and men receive the instruction as opportunities are favorable to them; and at the breaking out of war, those in the vicinity of their station of enrollment can at once be formed into a ship's company or into ships' companies, as the number will permit. Should the number of officers on the active list not be sufficient for the duties in connection with the Naval Reserve, the Secretary of the Navy should be empowered to employ those officers upon the retired list who are capable of performing these duties. These officers while so employed should receive the sea pay of their grade, which rate of pay should be that assigned to all officers serving on the training Reserve ships.

The bills before Congress to create a naval reserve of vessels will, I hope, attain this end, but the expense of shipbuilding in this country, together with that of running the ships after they are built, is so great compared with that of foreign ships, that it appears to me impossible to compete successfully with them without large subsidies or bounties from the Government. Consequently we cannot look for much aid from this source in time of war. Yet the mercantile marine is about our only source for vessels for the Reserve, and to place it on a respectable footing has engaged the attention of some of our ablest statesmen. A solution of the problem will be reached when the interests of trade favor the industry; in the meantime would it not be advisable to remove the duties from shipbuilding materials, and thus by removing part of the load from this branch of our trade, encourage it in its struggles to regain its once proud footing? The plan of a payment of a sum for every ton of those vessels built in accordance with instructions from the Navy Department is certainly a good one as far as it goes, but what is to maintain these vessels after they are built? The protectionist and freetrader will each give such excellent arguments that one not a political economist might be well pleased with the plan of either. Steamers in the coasting trade, steam yachts, and tugs might be put upon the Reserve list, as mentioned in the paper, and would in various ways be useful in time of war.

The plan for a Naval Reserve that will commend itself to Congressmen and to the country must be simple and comparatively inexpensive, easily understood by the landsman and readily explained by a Representative to his constituents. As the idea is a new one in our country, Congress would be more willing to approve it if a failure would not involve much expense. If the plan proved successful, it could be enlarged as its merits became apparent.

Lieutenant-Commander C. H. Stockton, U. S. N.—*Mr. Chairman and Gentlemen:*—I wish to preface my remarks upon the paper read by Captain Cooke, by saying that, though I differ from him in regard to the relative importance of this question, and also in regard to some points of its treatment, I desire to express my appreciation of the intelligence and zeal with which he discusses

the subject, and my general belief in the value and importance of a Naval Reserve to supplement the regular naval forces of the nation. I say supplement, for my only fear is that it may attain an undue prominence in the naval questions of the day, to the detriment of more vital matters.

The first inquiry that comes to my mind, after the reading of the paper, is concerning the wisdom, to say the least, of the ground taken by the writer, of linking the question of governmental aid to the construction and maintenance of naval vessels in reserve in time of peace, with the fiscal questions of subsidy and protection to shipbuilding and shipowning.

The question of cheapening the cost of shipbuilding and owning by the reduction in the cost of the raw or partly shaped and manufactured material which enters into the ship, instead of the provision of a system of bounties, is at least a debatable one, and to my mind should not be allowed to complicate the subject, which, from our point of view, is a purely professional matter and not a question of fiscal politics. The formation of a Naval Reserve by encouraging the construction of a certain type or types of vessels for war purposes is, to us, a military matter, to be treated as such, and I think especially to be separated from any advocacy of a paralleling in this country of the French bounty system, with its consequent want of success.

With the uncertain and varying policy generally shown by Congress toward the Navy, it seems wise to me that in advocating a Naval Reserve we should ask that this Reserve, composed of vessels constructed by private shipowners, aided by the Government, serving as trade carriers in time of peace, should be the source from which we would draw mainly, if not entirely, our despatch vessels, our transports, our depot ships, our commerce destroyers, and even our rapid cruisers.

As matters are going, it seems to me the duty of the men of the naval service to devote time and talent now, and first of all, to the advocacy of the construction of battle ships as the regular naval force of the country, so that we shall meet the war vessels of other navies with vessels that are at least their peers in every way. We must meet naval force with naval force, and not naval strength with naval weakness, otherwise the rapid cruisers that are being constructed at present, and about whose utility I fear at times we delude ourselves, will be rapidly engaged in seeking home ports to avoid meeting certain destruction from the armored and able-bodied commerce protectors of the enemy. I say home ports, for we have no coaling stations or harbors of refuge away from home that we can control or defend.

It seems almost hopeless to expect that we will get, by the action of Congress, both the strong and the weaker class of vessels, so let us concentrate our efforts first upon the strongest vessels for the regular navy, and *then*, as a secondary naval line, favor the formation of the Naval Reserve and volunteer fleet, built for auxiliary war purposes in war-time, and for trade purposes in time of peace; the conformity to certain naval regulations being duly compensated by the general Government. But in advocating the latter, do not let us lose sight of the essential element and unit for maritime combat so well described by Admiral Jurien de la Gravière, "as a ship covered with armor for protection

and defense; carrying gun, ram, and torpedo for defiance; with powerful machinery; with abundant provision of fuel for independence and duration of speed, and not restricted by its construction to place, weather, or state of the sea." Is it necessary to add that no nation determined to defend its coasts is free to renounce a combat upon the high seas? and furthermore, that the fighting unit just referred to, or its closest approximation, can only be provided by an expenditure of time, skill, and money?

In resuming the examination of the paper, let me call attention to another phase of the argument offered in favor of an indiscriminate tonnage subsidy to our mercantile marine. If this were given, a much larger and special subsidy would have to be given for vessels to form the Naval Reserve, as with equal subsidy no shipowner would incur the additional expense and probable limitations. It is much wiser to confine the governmental aid to the reserve vessels, for which an equivalent is thus returned, and not attempt an artificial stimulant to the whole mercantile marine.

The proposition of the writer to limit the *personnel* and *materiel* of the Naval Reserve to national control is, I believe, a wise one. It is the duty of the general Government to "provide for the common defense," made a sacred obligation by the Constitution, and that alone should place especially the *materiel* under the charge of the national administration, charged as it is already with the registry and responsibility of all vessels carrying the American flag.

The remarks of the writer in regard to the necessity and wisdom of due preparation for the defense and protection of our interests by the development of our naval strength cannot be too often repeated. Nowhere in the world is presented to inimical naval powers so strikingly the combination of wealth, inviting cupidity, with weakness, inviting attack, as on the sea-coast of this great country at the present day.

All of our resources for protection and defense, now while we can, should be thoroughly developed. We should sturdily resist all undermining attacks upon our naval educational establishments. We should more closely link the officers and men of the revenue marine to us both in time of peace and war; we should bind the interests and services of the merchant marine with us in peace, and more especially in war; and above all, if Congress should fail to realize and provide for the immense work that will be required from the Navy in time of war, in the protection of our coasting and foreign trade, the efficient guarding of our enormous sea-coast, and the defense of our rich seaports; let us, nevertheless, not fail to proclaim aloud the country's need for battle ships so that the enemy's ships may be met by vessels in all respects their equal, and our men-of-war be not compelled to meet destruction or defeat, or seek safety by inglorious flight.

Prof. R. H. THURSTON.*—*Mr. Chairman and Gentlemen*:—I have read the paper of Captain Cooke with all the interest and awakened earnestness that, in my opinion, must to-day be felt by every real friend of our country. To me it seems marvellous that our people, and especially so many of our legislators

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in Congress, can remain, as they actually do remain, absolutely blind and indifferent to the fearful dangers to which their supineness and folly are exposing our whole nation. We boast of our intelligence, and our neighbors are laughing at our stupidity and ostrich-like confidence. We are anxious lest our treasury should overflow into the purses of undeserving citizens, and we leave our coasts absolutely defenseless against the weakest of possible foreign foes. We talk loudly of our patriotism and crack our Fourth-of-July fireworks, and yet go into a wordy and possibly (probably, indeed) threatening dispute with a neighbor already a thousand times better prepared than we to cross the border in case of sudden war, and ready to lay waste a thousand provinces and cripple for a generation our most important industries and lines of trade. Could any idiot, saving his pennies by hoarding at the expense of the sacrifice of all that makes life worth living, and by risking his every possession and hope, be guilty of greater folly ?

A Naval Reserve we do most certainly need, and it is a good time to agitate in favor it, even though we have not yet a decently large and reliable nucleus for the Navy that it should be prepared to reinforce. How that Reserve shall be secured and maintained is a question that will become vital just as soon as it is rendered certain that we are to be permitted to hope for its establishment, and this is a good time to discuss the various methods of establishing and maintaining it.

The United States has here a more difficult problem to deal with than has Great Britain, that nation which, even more than our own, is most vitally concerned in the maintenance of a reliable naval establishment. The business aspects of the matter are such as favor her and tell strongly, perhaps fatally, against us. Our people can use their capital vastly more profitably in the internal industries of the country than on the ocean, and capital never of itself goes permanently into channels in which it cannot flow smoothly, with prospect of permanence of current toward the profitable lines in trade. Marine transportation can never become profitable to our people until the value of capital, as measured by the rate of interest and by the normal profits of business, settles down to a level with that of capital possessed by competing nations. This latter state of things is gradually being approached, but we may hope will not be reached until our competitors among nations shall have attained the state of general civilization and prosperity that to-day distinguishes the United States. Were it attained, it would mean the reduction of our people to the condition of those of European countries.

A Naval Reserve must, therefore, be created by artificial aids in so far as we are dependent for it upon trans-oceanic lines of ships. Whether we can wisely and prudently assume to tax ourselves to place in the pockets of a few of our citizens the difference between the natural earnings of capital in trans-oceanic trade and the natural product of capital in internal industries I am not quite sure ; but of this *I am* sure, that it were far better to expend a thousand millions in such a manner than to throw away that thousand millions in a war that might cripple the industries of the globe by breaking up the great lines of communication and transportation, by distorting the now smooth and natural

network of our own manufactures and trades, by gleaning out and destroying the flower of our own citizen body—those who would be first driven by patriotic sentiment into the contest and probably to certain destruction—and, worse than all, turning back the current of civilization for the world by more than the period during which ourselves and our antagonists would be thrown back toward barbarism, just at a time when we had begun to suppose that the introduction of the custom of arbitrament of national disputes had brought to an end national strife. Nations do not arbitrate where the more powerful can see clearly that the other party is too weak to defend himself.

It is worth while to consider to what extent we may first secure a Reserve by proper management of the merchant navy already existing, growing, and probably likely to continue permanently to grow, in our coastwise trade. Its ships are daily becoming larger and more numerous, its officers and men more and more efficient, and a careful adjustment of the regulations controlling it and its internal competing lines of transportation may possibly do something for us in this direction. I am not at all certain that we can hope for very much, far less for adequate assistance; but the question may nevertheless be worthy of study. I am myself inclined to believe that a carefully devised system of encouragement of direct trans-oceanic lines, especially to other than European countries, by at the same time opening and promoting foreign trade with them while furnishing us with a naval militia, would be the most safe and satisfactory plan, and that it would, next to the provision of the desperately needed coast defense by fortifications and a navy, be the best possible direction of expenditure of that somewhat uncertain growth of the "surplus" about which some of our most intelligent but, to my mind, mistaken statesmen are so seriously alarmed. The one encouraging fact, in the present alarming situation, is that our army and navy officers are so far breaking through the traditional abstinence from discussions affecting matters in the hands of our legislators, to temperately and clearly set forth the results of their own observation and thought, in such manner that they, who are naturally our best advisers as experts in the art of war and of defense, shall exert a wholesome influence in awakening that patriotism and that statecraft which have been for a quarter of a century dormant among those bodies of our representatives to whom we look ordinarily for examples of the most noble sentiments. The United States can never, and will never, desire to do more than defend country, home, and people against aggression; our policy is of necessity as well as of choice one of peace; but we can only be safe when we are prepared to meet the strongest and most enduring of possible aggressors, and when it shall be plainly seen that we cannot be safely attacked by any nation on the globe, or by any combination of possible enemies. The cost to the nation of such safety is a matter of comparatively insignificant importance.

When our older, wiser, more steady and trustworthy officers in the Navy and Army are taken into the councils of the nation; when our wisest and most patriotic citizens exert that influence which they have only to take into their hands to make felt most effectively; when the educated men of the country contribute their part to the general fund of patriotism; when the youth growing

up around us are as carefully bred to love their country as to become useful citizens and successful men of business: then we may hope to find ourselves safe behind impregnable walls of material and moral defense, and then only may we hope to lead in the great movements of modern national growth and civilization.

The tone of these comments upon the paper which has preceded may seem here somewhat out of place; yet I am sure that every member of this body will, as these thoughts are suggested, see that after all they are vital thoughts for us and for our countrymen.

W. THORNTON PARKER, M. D.—*Mr. Chairman and Gentlemen*:—I have read with great interest the paper of Captain Cooke, U. S. N., on the U. S. Naval Reserve, which, through your courtesy, I am invited to express my opinions upon in writing. The subject is unquestionably of national importance, and must sooner or later, unless we are hindered by ignorant legislation, become a part of our national defense.

In considering the matter, however, we must go back to proximate principles. Unquestionably this creation of the Naval Reserve, while it is advantageous for the best interests of national defense, and must act as a wholesome influence to encourage proficiency and general excellence in the merchant marine, must have, like everything else, a base of supplies. It must have in the first place a well organized and disciplined merchant marine to draw its recruits from. I do not mean to claim that all its supplies of men must come from the merchant marine or from discharged U. S. sailors, for it is evident that the intention is to follow very closely the recruiting system for volunteers; but there must exist, so to speak, a marine atmosphere. Just as in the Rocky Mountains no Naval Reserve would be thought of, so in sections of seacoast where commerce had been rendered so dead by unwise protective legislation that sailors had practically disappeared—the interest in a Naval Reserve would be absolutely nil. It is of vital importance that legislation to resuscitate our commerce and protect and improve our merchant marine shall go hand in hand with this laudable and necessary movement to create, what has been needed for more than half a century, a Naval Reserve. If we consider the condition of the German merchant marine and the German Navy at the close of our War of the Rebellion and its present admirable but still improving condition in 1888, we can readily understand and have powerful arguments to offer for national legislation for our unfortunate merchant marine of to-day. Reckless neglect and indifference on the part of the Government, absence of intelligent and patriotic legislation, has done its work to present what was once the best merchant marine of the world in a condition of dilapidated worthlessness, if not in well-nigh hopeless disorganization and demoralization. The Government of Germany showed great wisdom and prudence in its determination to have a navy. By patient, plodding, wise, and generous legislation, free ships, subsidies, and as many naval and marine institutes as could be operated, the dream of the German Government has been more than realized, and a superb and effective navy is the gratifying result.

To go back again to proximate principles. The *morale* of the merchant marine must first be looked into. Take a German sailor ashore; he is dressed in his best clothing, he has his pay in his pocket or his bank-book to show that it is in safe keeping, and he endeavors in every way by his conduct and general appearance to show to the community that he is a respectable, decent man, and that he respects his vocation and respects himself. Look at the other picture of a drunken Yankee sailor on shore; poorly clad, his pockets empty or shortly to become so, with a hang-dog, worried look in his dissipated face, and steering straight for the lowest slums of vice and dishonor in the city. He winds up at length uncared for, miserable, sick, and well-nigh in delirium tremens, at some vile den yclept a *sailor's boarding house.* Over this dreadful place presides a brace or more of the most miserable and brutal masters, who soon possess themselves not only of all our poor Jack has on his person, but the body itself, and the wages it may earn for weeks and perhaps months to come. This is not an overdrawn picture. In spite of the noble-hearted efforts of many good people to establish here and there houses and homes of refuge for our sailors, no real practical good can be accomplished until the Government follows line by line the course which has proved so successful in Germany, and offers insurmountable barriers of protection for our sailors. Men of courage wherever real danger is to be met and overcome, with records for gallant actions the envy of the sailors of the world, they succumb in port to these heartless and miserable cowards who should receive absolutely no better reward than that meted out to pirates a hundred years ago—hanging in chains, and burial between high and low water mark. Pirates of the sea deserve honor beside such despicable, loathsome brutes who make our sailors mere junk for ready sale and barter. I must beg pardon for taking your valuable time in what may seem to many the relation of facts well known and well understood, but of the most baffling difficulty when a remedy is looked for.

We see, then, that reform in the merchant marine to secure a respectable name for our sailors is of the first importance. Wise legislation for the vexed question of shipping, and the cultivation of a decent and reasonable *esprit de corps* in our naval sailors and apprentices, are essential. We must never sink into the mistaken position of some nations whose ships often enter our harbors, but whose sailors are worthless and whose officers are inferior men, by supposing that if our officers are good men it matters little what the personnel of the sailors may be. "Hearts of oak" our sailors must have just as well as their officers. Manly, self-respecting men must they be, whether wearing the broad blue collar or the golden shoulder strap. Then we can look for a successful Naval Reserve when improvement has been begun at the bottom—the merchant marine must be healthy and effective. Undoubtedly the creation of an efficient and well disciplined Naval Reserve would be of the greatest service to the merchant marine, and an incentive to our young men to go to sea with some hope of an honorable calling. The sailors are useful at sea, but in the Naval Reserve we should have a force available for duty on shore in cases of emergency. When we look back at the history of our blue jackets we find pages of history relating many deeds of daring and gallant

battles fought on shore, and while the most enviable records of gallantry afloat are common on the naval archives, deeds of bravery on shore have been, and ever will be, recorded whenever opportunity offers. The Naval Reserve is needed now, but the pity is it has been needed for many years. Every patriotic and economic interest should be exerted in the organization of a powerful Naval Reserve as soon as possible, for the best interests of our nation in general.

Lieutenant-Commander W. W. REISINGER, U. S. N.—*Mr. Chairman and Gentlemen:*—I have read with great interest the very able paper by Captain A. P. Cooke, U. S. N., and agree with him in his presentation of the case. There is no longer any doubt as to the general demand for some immediate action looking to the establishing of additional means of defense for our now unprotected coasts and harbors, and for the increase of our naval power; nor is this demand confined to military circles. The organization of a Naval Reserve and of Volunteer Artillery and Torpedo Corps is a step in the desired direction.

The bill introduced by Senator Whitthorne covers nearly all of the ground as to the Naval Reserve. I would, however, like to emphasize that portion of his bill which is to be found in the closing words of Section 1, *i. e.*, "And all ex-officers and enlisted men of the Navy."

Captain Cooke says: "No reserves we can ever secure will be equal to men who have passed a term of active service on board ships of war." If this be true as regards the enlisted man, how much more so is it when applied to the officer who has been specially trained to command. In nearly every important seaport there are ex-officers of the Navy, line and staff, men who have had excellent records during their terms of active service, but who preferred civil life to naval life during peace, and who resigned, not under pressure, but of choice. There are many retired officers also of the same class who are unfit from physical causes to undertake extended cruises under various climatic influences, who might be of great service in the home ports. The services of these ex-officers and retired officers, whether of the line or staff, would be of great value, and their places in a naval reserve or volunteer corps should be clearly defined. I do not advocate any change in the existing laws regarding the status of these officers in the Navy proper, but have in view only their probable employment in the proposed corps and reserve.

Another point I beg leave to call attention to is the eminent fitness of the harbor of Newport, R. I., as a training station for all forces, Naval, Army, Naval Reserve, and Volunteer Artillery and Torpedo Corps. The fact that the Naval War College, Torpedo Station, and a large fort are located here, and the further fact that there exists plenty of enclosed water for large operations, will mark it as particularly suitable for our purposes, and in this connection I would urge the great importance of having every available vessel of the North Atlantic Squadron rendezvous here during the months of May, June, July, August, and September, as a general school of evolution and instruction. It might not be going too far to suggest that all of the new men-of-war now

being built, and all ships fitting out for foreign service, should spend a month or two with this fleet for a general "setting up" before their inspection and previous to their final assignments to duty. This fleet, in conjunction with the lectures at the War College and the experimental work of the Torpedo Station, will be an excellent school for all officers and men of the Regular Navy, and it is here, and when this fleet is assembled, that the officers of the Naval Reserve, and Volunteer Artillery and Torpedo Corps, should be ordered for their training.

Further, this harbor is an excellent place of rendezvous for such yachts as may be enrolled in the Reserves, and one month's or even two weeks' service with the fleet under an energetic Admiral would teach more of naval duties than a year of theoretical work or hap-hazard exercises. Such practical exercises as were inaugurated by Admiral Luce during this last summer would be of immense service. In all these drills the Admiral had the hearty co-operation of the officers of the Army and the Torpedo Station; and the officers in attendance at the War College had the full benefit of all that was done.

Landing parties from the fleet to attack positions defended by the army, mining and countermining, running batteries, night torpedo attacks, are all possible here, and if carried out with the new and improved weapons would command the attention of all officers. It is unnecessary to enlarge upon the advantages of such a squadron of manœuvre. It is perfectly feasible and involves no extra expense, except the trifle for mileage of officers ordered there. These officers will take away with them the knowledge there acquired, and will impart it to their crews and companies.

Lieutenant SEATON SCHROEDER, U. S. N.—*Mr. Chairman and Gentlemen:*—Among the many excellent points brought out in Captain Cooke's paper I would like especially to commend the paragraph in which it is suggested that, after a certain length of service, the enlisted men of the Navy should be eligible for duty in the Revenue Marine. I would suggest that the same plan could be adopted in regard to the Fish Commission, Coast Survey, and Light House vessels. In the past the sailor has usually adopted his calling in consequence of a certain restlessness of temperament, coupled with other less ambiguous attributes, which have led him to seek a life of adventure. This applies to a less extent now; and while it is perhaps desirable that a seafaring man should be possessed of a more or less roving disposition, that of itself will not always induce a supply of experts up to the demands that may be suddenly made, nor will it alone always provide just the class of men we want. The effort now (and I am happy to say I believe it to be successful) is to elevate the enlisted man morally, physically, and intellectually; in the furtherance of that idea, it would be an incentive to desirable young men to enter the Navy if they could feel certain that after learning their profession, and giving a certain number of years of military service in return, they would be assigned to duty where, while working equally hard and in kindred circumstances, they would be off our own coast and have an occasional chance to see their homes and families. There is nothing in the proposed duty to unfit them for future naval

work. In the Fish Commission and Coast Survey they would be absent from the guns and from the Naval Brigade; but one term of enlistment would not cause them to forget what they had been studying and practicing during three enlistments; like swimming, it would all come back on trial; and in the meantime their work in all other ways would be strictly nautical, and would furnish a diversion far from devoid of benefit to the individual man and to the service in consequence.

An experience of over three years as executive officer of the Albatross showed me what can be expected from those men. The crew, like the officers, were worked very hard, but most of them took great interest in the business, and were as zealous as any of the officers in, for instance, securing the results of a deep haul of the dredge by the electric light in a squally mid-watch. When the ship lay for a week at the Exposition Grounds at New Orleans, it was the enlisted men who showed the visitors about and explained intelligently the working of the steam and hand sounding machines, the dredging engines, trawls and tangles, the automatic sounding cups, thermometers and deep-sea water bottles, the submarine electric light, and seine and gill nets, etc. And when sightseers from the West and from all over the country asked if those fine looking, bright men were "common sailors," I was proud to answer, "Yes, they are representative Navy blue-jackets."

If the absence from what may be called the military part of their calling be undesirable, it would be a simple matter to have them take part for a month or so in the yearly evolutions on sea and land. And while in the Revenue Service a certain amount of drill could ordinarily be carried on, both with small arms and with the modern guns that should be supplied to those vessels, yet I would advise and strongly urge that both their officers and men should also take part in the annual squadron drills which I trust will become a fixed feature in our naval policy.

By this arrangement the number of well trained fighting men available immediately on the outbreak of hostilities would be increased by a number which, although not very large, would assist materially in leavening other less valuable contingents. It is in the power of the Navy Department now to apply this rule in manning the Fish Commission and Coast Survey vessels, and it is certainly desirable that appropriate legislation should enable it to do the same for those other services. There seems to be no good excuse for the maintenance of two national naval schools and nautical establishments; the members of each of these now separate corps should be able to do the work of all. No one will question the professional benefit to the officers of the Navy that would accrue from an increased opportunity to become familiar with our own coast, which familiarity can only be properly acquired from the ground itself and not from charts. Nor can the present revenue officers question the advantage to them of being able to extend their sphere of usefulness by being incorporated in the Navy. The fusion of these two services seems an almost essential feature in any practical scheme of coast defense; and I think the Institute would do well to throw the weight of its opinion in favor of that end.

Lieutenant W. H. BEEHLER, U. S. N.—*Mr. Chairman and Gentlemen:*—Captain Cooke's valuable paper on the Naval Reserve should enlist the hearty co-operation of the Navy and merchant marine. The methods advocated do not go into such details as we might desire, but the details of organization and strength cannot be elaborated until there is something definite upon which to base the organization. Discussion of the measure is therefore at the outset restricted to advocating the advantages and necessity of a Naval Reserve, and I think we all feel greatly indebted to Captain Cooke for the clear, concise statement of these advantages and the necessity for a Naval Reserve.

To assist in bringing the subject still more prominently into notice, I enclose herewith a list of mercantile cruisers of all countries having a speed of 14 knots or over, capable of being utilized as auxiliary cruisers in time of war.

BRITISH AUXILIARY CRUISERS (83).

Name.	Gross Tonnage.	When Built.	Speed.	Owners.
Etruria	7718	1884	19	Cunard S. S. Co.
Umbria	7718	"	19	"
Ormuz	6116	1886	18	Orient S. N. Co., White Star.
Alaska	6932	1881	17	Guion Line.
Aurania	7269	1883	17	Cunard Co.
City of Rome	8144	1881	17	Henderson & Co.
Austral	5589	"	17	Orient Co., White Star.
Victoria	6268	1887	17	P. & O. S. N. Co.
Britannia	6268	"	17	"
Arizona	5164	1879	16½	W. Pearce.
Orient	5389	1881	16½	Orient Co., White Star.
Servia	7392	"	16½	Cunard.
Rome	5000	"	16	P. & O. Co.
Carthage	5000	"	16	"
Valetta	5000	1884	16	"
Massilia	5000	"	16	"
Britannic.	5008	1874	15½	Oceanic S. N. Co.
Germanic.	5004	"	15½	"
Ravenna	3372	1880	15½	P. & O. Co.
Rohilla	3500	"	15½	"
Rosetta	3502	"	15½	"
Clyde	4124	1881	15½	"
Shannon	4189	"	15½	"
Ganges	4196	1882	15½	"
Thames	4104	"	15½	"
Sutlej	4194	"	15½	"
Ballaarat	4796	"	15½	"
Paramatta	4758	"	15½	"
Tasmania	4488	1884	15½	"
Chusan	4490	"	15½	"
Coromandel	4496	1885	15½	"
Bengal	4497	"	15½	"

Name.	Gross Tonnage.	When Built.	Speed.	Owners.
Orinocco...............	4477	1886	15½	Royal Mail.
Orizaba................	6500	"	15½	Pacific S. N. Co.
Oroya..................	6500	"	15½	"
Gallea.................	4809	1879	15½	Cunard.
Vancouver..............	5217	1884	15½	Mississippi & D. S. Co.
Glenogle...............	3749	1882	15½	McGregor, Son & Co.
Ancona.................	3128	1879	15	P. & O. Co.
Verona.................	3116	"	15	"
Arana..................	5026	1884	15	Shaw, Saville & Albion Co.
Tainui.................	5031	"	15	"
Iberia.................	4702	1873	14½	Pacific S. N. Co.
Liguria................	4688	1874	14½	"
Moor...................	3668	1881	14½	Union S. S. Co.
Parisian...............	5359	"	14½	Allan.
John Elder.............	4182	1870	14	Pacific S. N. Co.
Cuzco..................	3849	1871	14	Orient S. N. Co., White Star.
Chimborazo.............	3847	"	14	"
Lusitania..............	3832	"	14	"
Garonne................	3876	"	14	"
Sarmatian..............	3647	"	14	J. & A. Allan.
Adriatic...............	3887	"	14	Oceanic S. N. Co.
Baltic.................	3700	1872	14	"
Celtic.................	3886	"	14	"
Republic...............	3700	"	14	"
Sorata.................	4059	"	14	Pacific S. N. Co.
Potosi.................	4267	1873	14	"
City of Berlin.........	4521	"	14	Inman.
City of Chester........	4770	"	14	"
Australia..............	2730	1875	14	W. Pearce.
Zealandia..............	2731	"	14	"
Durban.................	2875	1877	14	Union S. S. Co.
Pretoria...............	3199	1878	14	"
Arab...................	3170	1879	14	"
Grantully Castle.......	3409	"	14	Castle Line.
Glenfruin..............	2985	1880	14	McGregor, Son & Co.
Mexican................	4668	1882	14	Union S. S. Co.
Tartar.................	4339	1883	14	"
Hawarden Castle........	4241	"	14	Castle Line.
City of Chicago........	5203	"	14	Inman.
Glengarry..............	3024	"	14	McGregor, Son & Co.
Avrangi................	4163	"	14	New Zealand S. Co.
Ruapehui...............	4163	"	14	"
Tongareiro.............	4463	"	14	"
Rimutaka...............	4473	"	14	"
Kaikoura...............	4471	"	14	"

Besides the above there are two 20-knot ships building for White Star Line, two 18-knot ships building for Inman Line, and two 17-knot ships building for P. & O. Co., a total (when completed) of 83 ships.

GERMAN AUXILIARY CRUISERS (24).

Name.	Gross Tonnage.	When Built.	Speed.	Owners.
Lahn..	5500	1887	18¼	N. German Lloyds.
Trave	5500	1886	18	"
Aller.	5500	"	18	"
Saale	5500	"	18	"
Werra	5109	1882	18	"
Fulda	5124	1882	18	"
Ems	4728	1884	18	"
Eider	5129	"	18	"
Elbe	4897	1881	17	"
Preussen.	4500	1886	15½	"
Bayern	4500	"	15½	"
Sachsen	4500	"	15½	"
Hammonia	4247	1882	15½	Hamburg-American S. S. Co.
Rhein	2901	1868	14	N. German Lloyds.
Main.	2899	"	14	"
Donau.	2896	"	14	"
Oder	3158	1874	14	"
Necker	3120	"	14	"
Westphalia.	3186	1868	14	Hamburg-American S. S. Co.
Frissia	3256	1872	14	"
Lessing.	3827	1874	14	"
Gellert	3533	"	14	"
Wieland	3504	"	14	"
Rugia	3467	"	14	"

ITALIAN AUXILIARY CRUISERS (12).

Name.	Gross Tonnage.	When Built.	Speed.	Owners.
America	5528	1883	18½	Bought by Government.
Persea	3950	"	16	Gen. Italian Nav. Co.
Oriono	3946	"	16	"
Regina Margherita..	3577	1884	16	"
Domenico Baldino..	4580	1882	15	"
Vincenzo Florio	2840	1880	14	"
Raffaele Rubattino..	4538	1883	14	"
Washington	2845	1880	14	"
Archimede	2837	1881	14	"
China	2837	1883	14	"
Indipidente..	2837	"	14	"
Sottanto	2847	"	14	"

BELGIAN AUXILIARY CRUISERS (3).

Name.	Gross Tonnage.	When Built.	Speed.	Owners.
Westernland.	3691	1883	14	Belgian-American S. N. Co.
Rhynland.	3689	1879	14	"
Belgenland	3692	1878	14	"

SPANISH AUXILIARY CRUISERS (6).

Name.	Gross Tonnage.	When Built.	Speed.	Owners.
Cuidad de Cadiz.....	3084	1878	14	Spanish Transatlantic Co.
Antonio Lopez.......	3460	1881	14	"
Catalina	3488	1883	14	"
Mexico	4142	1884	14½	Spanish-Mexican Flag.
Oaxaca.....	4133	1883	14½	"
Tamaulipas	4133	1883	14½	"

BRAZILIAN AUXILIARY CRUISERS (2).

Espiritu Santo........	1713	1875	14	Brazilian S. N. Co.
Mauvao	1719	1883	14	"

FRENCH AUXILIARY CRUISERS (28).

La Bourgogne	7200	1886	18	Gen. Transatlantic Co.
La Champagne.......	7200	"	18	"
La Bretagne	7200	"	18	"
La Gascogne	7200	"	18	"
La Normandie	6200	1882	16½	"
Amerique	4517	1865	15	"
Melbourne.............	3847	1882	14½	Messageries Maritimes.
Natal......	3829	"	14½	"
Calédonian.......... ...	4008	"	14½	"
Yarra	4016	"	14½	"
Sydney	4021	"	14½	"
Salazie..........	4037	"	14½	"
Oceanien...............	4039	1884	14½	"
Orénoque	3705	1874	14	"
Equateur	3725	1875	14	"
Crugo........	3666	1878	14	"
Niger........	3532	1871	14	"
Senegal......	3556	1872	14	"
Gironde	3059	1869	14	Gen. Transatlantic Co.
France	4517	1865	14	"
St. Laurent............	4067	1866	14	"
Labrador	4517	1865	14	"
Canada......	4047	"	14	"
St. Germaine	3554	"	14	"

Four 17-knot ships building for Messageries Maritimes.

AMERICAN AUXILIARY CRUISERS (6).*

City of Pekin.........	5080	1874	14	Pacific Mail S. S. Co.
City of Sydney	3017	1875	14	"
City of Para	3532	1878	14	"
City of Rio Janeiro,	3548	"	14	"
San Pablo..............	3119	1882	14	Pacific Improvement Co.
San Pedro	3119	"	14	"

* The London periodical from which this list is copied is in error about American ships; there are 20 American steamers of over 14 knots on the Atlantic coast.

RECAPITULATION.

83	English ships,
24	German "
28	French "
12	Italian "
3	Belgian "
6	Spanish "
2	Brazilian "
158	foreign vessels available for cruisers,

all suitable for cruisers in time of war, and only six [26] American steamers, all of which are on the Pacific coast.

This list is from the *Army and Navy Gazette*, but I believe these vessels are all regularly enrolled by the different governments, under whose flag they sail for use as auxiliary cruisers in time of war.

Our people do not invest in ships, chiefly because they have other channels for their enterprise and capital which they find to pay, and they do not recognize the advantages to be gained by investing in ships. If we can convince the people that it would "pay" to invest in building fast steamers, they will do so. But in view of our tariff and protection policy, it is claimed to be impossible to reap any adequate return from money invested in American ships. A subsidy in some form must be given in order to make this industry attractive to our capitalists, and if it is clearly established that Government aid will develop the industry, all opposition on the part of those who might feel jealous of the aid given will be removed by showing how each and every industry is favored by subsidy to steamer lines.

Every industry is represented in the production of a modern mail steamer. Shipbuilders put the material together, but the production of this material and the fittings for the equipment employ men from every trade. Every class of labor is requisite, and when completed, the officers and crew require subsistence and consume such quantities of the farmer's produce that it can be clearly demonstrated to be to the interest of the farmer to encourage the organization of a Naval Reserve, together with subsidy to American steamers. The quantities of butter, eggs, lard, bacon, hams, poultry, beef, vegetables of all kinds, flour, biscuit, etc., necessary for a single steamer will necessitate a supply of the farmer's produce and furnish new markets to dispose of the surplus with which he is so much burdened.

American steamer lines should compete with those of other countries, and instead of six American vessels of fourteen knots speed we ought to have at least 200, which would take the surplus productions to a market which would be highly profitable.

Most of the canned goods carried by these 158 steamers mentioned are from the United States; foreigners find it to pay to tranship these goods and indirectly convey them to markets which we should supply directly at much less expense to the foreign market and therefore in much greater quantities.

An experience in my last cruise will illustrate this feature. As caterer of

the wardroom mess of 16 officers, I managed to save several hundred dollars in two bills of mess stores sent direct from New York by sailing vessel. In many cases the cost of articles in Montevideo was just double that at New York; condensed milk was bought at $2 a dozen, including freight from New York, while it sold for $4.80 a dozen in Montevideo. There was no steamer line from New York to Montevideo then, nor at present, and the people of Uruguay and the Argentine Republic use condensed milk from Switzerland, a very inferior article for which they pay 30 cents per can, in preference to the superior American milk at 40 cents a can. If there were an American line of steamers direct to New York this milk would be sold at a good profit at 20 cents a can.

This may seem to be an insignificant item, but the same thing applies to all American produce (I mention this as one that came under my personal observation), and if we can only convince our producers that foreigners are shutting the markets of the world from our produce by their subsidized lines of steamers, the merchants, farmers, mechanics, and laborers will rise up as one man and demand the restoration of American ships, no matter what subsidy may be necessary. The Naval Reserve will then have a solid basis and the supremacy of our glorious country will be manifest throughout the world.

Upon motion duly seconded, it was

Resolved, That a vote of thanks be tendered the Seawanhaka Corinthian Yacht Club for the kind permission to use their rooms for the purpose of the meeting.

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ALUMINUM BRONZE FOR HEAVY GUNS.

By A. H. Cowles.

DISCUSSION (Continued).

NEWPORT BRANCH.

February 1, 1888.

Lieutenant Karl Rohrer, U. S. N., in the Chair.

The Chairman.—In introducing the lecturer of the evening I may, perhaps, be pardoned a word or two of explanation. To most of us this explanation is entirely unnecessary, but that we may all enjoy an equality of acquaintance, I beg to remind you that he is one of the inventors of the electric furnace, and that, in conjunction with his brother and Professor Mabery, he has brought within economic reach a metal possessing such extraordinary qualities that it has been spoken of as the metal of the future. Possessing great lightness, great tenacity, and great resistance to corrosion, its application to many phases of construction is but a question of time. Others before him have produced the metal aluminum, but on the laboratory scale and in quantities so small as to be practically restricted to museums. He, however, offers it and its alloys to the engineering world in commercial quantities, at a price which permits its employment in structures where its particular qualities are demanded, and I understand that soon it will become still cheaper.

It is hardly necessary to say that the introduction of this metal into the list of those available is a notable event in the history of metallurgy. To us of the naval service this event is of peculiar significance, as the lecturer proposes the employment of aluminum bronze as a substitute for steel in modern guns. This project was first laid before our Institute in October last, and the discussion which ensued created such interest at home and abroad that further light on the metal itself, as well as upon its adaptability to ordnance, was thought desirable. In consequence the lecturer has been kind enough to appear again before the Institute, with new facts and new specimens of whose characteristics he himself will speak.

Gentlemen, I have the honor to present to you Mr. Alfred H. Cowles.

Mr. ALFRED H. COWLES.—*Mr. Chairman and Gentlemen:*—There are so many present who can more ably and impartially criticise the papers presented at the Annapolis meeting than my brother or myself, that I will not undertake to speak further in regard to them. We endeavored to make it clear that our position was not that of attacking the present method of making guns of steel as recommended by our government ordnance officers. We consider, on the contrary, that the all steel "built-up" gun is the product of the best known practice of the present day. We are presenting our subject to you, not as gunmakers, but as the producers of a new class of alloys having combinations of physical properties which we believe render them superior to steel in the fabrication of guns, inasmuch as they can be perfectly cast to the form of a completed gun. Were we gunmakers, we would have first produced a gun and pointed out its merits as a basis for discussion. But as producers of these new metals, we desire that the ordnance officers and the gunmakers may become familiar with their properties, learn wherein they are applicable to their work; and we hope that as an outgrowth of this discussion a number of experimental guns will be produced in Europe and in this country during the ensuing year.

Through the courtesy of Engineer-in-Chief Melville of the Navy, I am enabled to give you the following report of Chief Engineer W. H. Harris upon some tests of extraordinarily large bars of metal that were recently tested at the Watertown laboratory to determine the value of the alloys as propeller blade metals. It is generally conceded that small bars of metal are stronger and more ductile than large bars of the same metal.

The data given by authorities on this point is very meagre.* Hodgkinson found that in cast-iron bars of one, two and three-inch cross section of area this loss of strength was very great; the relative tenacities were as 100, 80 and 70. James, in repeating the experiment, obtained the figures of 100, 66 and 60. Captain Eads† broke a life-size forged steel member of the St. Louis bridge, and obtained a tensile strength of only about one third that shown by small bars cut from the same piece. The small bars showed great ductility, which failed to develop in breaking the life-sized member.

NAVY DEPARTMENT,
BUREAU OF STEAM ENGINEERING,
WASHINGTON, *December* 20, 1887.

Sir:—In obedience to orders of the 22d ultimo, I have visited Watertown, Mass., and Lockport, N. Y., to witness experiments at the former place upon specimens of aluminum bronze and brass submitted for tensile tests by the Cowles Electric Smelting and Aluminum Company, of Lockport, N. Y., which place I visited after the tests at Watertown were completed.

In competition with the bronze specimens furnished by the above company, the Bureau directed that six specimens of tin bronze usually used for propeller castings in the U. S. naval service, be tested under like conditions.

* Thurston's Materials of Engineering, Vol. II, p. 442.

† See last edition of Trautwine's Engineer's Pocket-Book.

All specimens tested were 15 inches in length between reference marks, and if finished all over, were 1⅞ inches diameter; those which were left as taken from the sand were slightly in excess of this diameter, 1.93 inches being the greatest diameter recorded.

A tabulated statement of the results of the tests is appended to this report.

A comparison can be made between the aluminum bronze castings marked D, and the tin bronze marked 4, 5 and 6, all these specimens being left as they came from the sand.

The average of the three tin bronze specimens being: T. S. 22,400; E. L. 13,000; elongation in 15 inches, percentage 3.34; reduction of area 7.98 per cent.

Comparing the specimens marked 9, 10 and 13 D with the above: 9-D shows 53,000 — 22,400 = 30,600 pounds = 136 per cent greater tensile strength. 19,000 — 13,000 = 6,000 pounds = 46 per cent greater elastic limit. 6.2 — 3.34 = 2.86 = 85 per cent greater elongation. 15.5 — 7.98 = 7.52 = 94 per cent greater reduction of area. 10-D shows 69.930 — 22,400 = 47,530 pounds = 212 per cent greater tensile strength. 33,000 — 13,000 = 20,000 pounds = 153 per cent greater elastic limit. 3.34 — 1.33 = 2.01 = 60 per cent less elongation. 7.98 — 3.3 = 4.68 = 59 per cent less reduction of area. 13-D shows 46,500 — 22,400 = 24,100 = 107 per cent greater tensile strength. 17,000 — 13,000 = 4,000 = 30 per cent greater elastic limit. 7.8 — 3.34 = 4.46 = 133 per cent greater elongation. 19.6 — 7.98 = 11.62 = 145 per cent greater reduction of area.

All of the above aluminum bronzes can be worked hot or cold, but no experiments have been made, to my knowledge, to determine their strengths after such working.

It makes sound and sharp castings; its greater tensile strength allows the use of thinner and consequently lighter blades for propellers, and its great ductility allows of its being bent nearly at right angles without showing cracks or flaws.

I have no knowledge of any alloy of copper which as a casting combines the qualities which this material possesses.

At the works at Lockport, N. Y., I found that 30 tons of the high grade aluminum bronze or 90 tons of aluminum brass per month is the present capacity of the works; but in the designing of the plant, arrangements were made for an increase of 100 per cent in product, which the manager of the works, Mr. Dudley Baldwin, Jr., states can be effected in ninety days.

Very respectfully,

(Signed) Wm. H. Harris,
Chief Engineer, U. S. N.

Engineer-in-Chief Geo. W. Melville, U. S. N.,
Chief of Bureau of Steam Engineering,
Navy Department, Washington, D. C.

	Mark or Number.	Approximate Composition.	Length between Reference Marks. Inches.	Diameter. Inches.	Area. Square Inches.	Tensile Strength. Lbs. per Square inch.	Elastic Limit. Lbs. per Square inch.	Elongation. Per cent. in 15 inches.	Reduction of Area. Per cent.	Diameter at Fracture. Inches.	
Aluminum Bronze or Brass.	1C	Cu 91.5, Al 7.75, Si .75.	15	1.875	2.7612	60,700	18,000	23.2	30.7	1.56	Chill Castings.
	7C	Cu 88.66, Al 10, Si 1.33.	15	1.875	2.7612	66,000	27,000	3.8	7.8	1.8	
	9C	Cu 91.5, Al 7.75, Si .75.	15	1.875	2.7612	67,600	24,000	13.00	21.62	1.66	
	10C	Cu 90, Al 9, Si 1........	15	1.875	2.7612	72,830	33,000	2.40	5.78	1.82	
	11C	Cu 63, Zn 33.33, Al 3⅓, Si .33, ...	15	1.875	2.7612	82,200	60 to 73,000	2.33	9.88	1.78	
	13C	Cu 92, Al 7.5, Si .5. ...	15	1.875	2.7612	59,100	19,000	15.1	23 59	1.64	
	9D	Cu 91.5, Al 7.75, Si .75..	15	1.9	2.84	53,000	19,000	6.2	15.50	1.75	Dry Sand Castings.
	10D	Cu 90, Al 9, Si 1........	15	1.89	2.81	69,930	33,000	1.33	3.30	1.86	
	11D	Cu 63, Zn 33.33, Al 3.33, Si .33.	15	1.9	2.84	70,400	55,000	0.4	4.33	1.86	
	13D	Cu 92, Al 7.5, Si .5. ...	15	1.93	2.93	46,550	17,000	7.8	19.19	1.73	
Navy Yard Bronze.	1	Cu 88, Sn 10, Zn 2......	15	1.875	2 7612	18,000	10,000	2.5	4.7	1.83	Green Sand Castings.
	2	Same	15	1.875	2.7612	24,500	11,000	8.2	6.8	1.81	
	3	Same.............	15	1.875	2.7612	22,500	11,000	5.8	10 89	1.77	
	4	Same.............	15	1.88	2.776	23,000	13,000	4.0	10.36	1.78	
	5	Same.............	15	1.88	2 776	20,570	13,000	2.33	6.3	1.82	
	6	Same............	15	1.88	2.776	23,750	13,000	3.7	7.3	1.81	

The following table shows the results of tests on the hardness of the large bars:

Aluminum bronze or brass—

Mark.	Hardness of Head.	Hardness of Stem.
1C	9.39	13.85
7C	14.12	14.26
9C	11.18	13.59
11C	14.69	10.60
10D	17.08	16.07
Navy Yard Bronze—		
No. 1	3.33	3.33
No. 5	3.67	6.56

The bars furnished by the Government and marked "navy bronze" were carefully cast at the New York Navy Yard and under the inspection of an officer detailed for that purpose, and were exceedingly fine castings. You will notice that they are of the composition of ordinary gun bronze.

Bars of this metal of $\frac{79}{100}$ inch diameter (such as are usually tested) would have about 39,000 pounds tensile strength to the square inch, 13,200 pounds elastic limit, and from 25 to 33 per cent elongation, thus showing a falling off in these large bars of about 45 per centum in strength and a very great lessening in their elongation. The aluminum alloys likewise show a lower strength and ductility than was obtained from bars one third of an inch in diameter that were tested in the works of the Cowles Electric Smelting and Aluminum Company at the time the large bars were cast; these small bars

ranged from 12 to 35 per cent higher in strength and much higher in ductility than was developed by the Watertown tests.

At the Annapolis meeting it was claimed that the present form of "built-up" steel guns had all the strength needed. I merely call your attention to the fact that since the date of that meeting we have learned of the bursting of the De Bange 14-inch steel gun at Calais, France. The bursting in this case was not the blowing off of the unhooped muzzle, but was just forward of the trunnions and through the body of the gun.*

In pointing out the defects in the present method of gun building, it is our endeavor to ascertain the cause of such accidents as this and learn if the "built-up" steel guns cannot be improved upon, and their defects removed, by the substitution of a metal whose physical properties surpass those of steel, and that may be cast as a whole. In doing this, it is not to be denied that the present "built-up" steel gun is superior to anything heretofore produced.

In Notes on the Construction of Ordnance No. 41, issued last April by the War Department, we find that Mr. J. E. Howard, of the Watertown testing laboratory, by his ingenious and scientific methods has made two valuable discoveries which bear directly upon the present method of fabricating "built-up" guns. He showed (page 19) that compressive and tensile tensions begin to relieve themselves when steel is subjected to 428 degrees Fahrenheit. The effect of long-continued heating at lower temperatures than this, or often repeated heating such as the bore of a gun is subjected to, has never, to my knowledge, been definitely determined, yet rumors in old treatises on ordnance have it that the internal strains set up in casting cast-iron guns relieve themselves with the varying heat of winter and summer. It is for those who use the guns to state whether the bore is ever subjected to this temperature.

Mr. Howard has further demonstrated (pages 6 and 31) that oil tempering a ring of gun steel throws the entire surface immersed into an initial state of compression, and the inner portions of the metal into a reverse state of initial tension. In a case where the bore of a tube was quenched while at a bright red heat with water, a range of tensions and compressions from the outside surface to the inner surface of 109,874 pounds to the square inch were found to exist. The presence of these initial tensions in oil-tempered steel rings shows that a gun built of an aggregation of such rings cannot have the nicely calculated variation of compressions and tensions from the centre outward that is sought, since the parts before they are assembled have each within themselves initial strains. The initial strains within each ring may be altered by the shrinkage process, but they only exist in another form to destroy the uniformity of the result desired.

It seems strange that the molecules in one part of a mass of steel such as that here referred to should have a repellent action for each other up to their elastic limit, while in another part of the same mass they should have a greater affinity and endeavor to pull themselves closer together with no other apparent cause than having been cooled quicker or slower by quenching; and further, that the strength and elastic limit of the metal should thereby be raised.

* Army and Navy Journal, December 17, 1887.

One is led to regret that more of this exact work is not done, and that all the physical properties of many of the bars of metal tested by our Government and the exact chemical composition of the same are not determined. By all the physical properties I mean those that are now ordinarily determined so nicely, together with the specific gravity, the specific heat, electrical conductivity, the coefficient of expansion, and thermal conductivity. Such work would soon accumulate a mass of data that would give us a deeper insight into molecular physics, might enable us to tell the physical properties of a combination of metals from those of the elements, and would certainly greatly aid the metallurgist in producing specified results.

I thank you, gentlemen, for the many courtesies extended to me and the interest thus far manifested in the subject I have had the good fortune to present to you.

To the Members of the U. S. Naval Institute.*

Gentlemen :—I thank you for the honor you have paid me in sending me a copy of the very interesting discourse that Mr. Alfred Cowles delivered before you on the 27th of last October at Annapolis.

On this subject I beg your permission to say a few words as to the history of aluminum bronze and its applications, and I will close with some observations on the special question which is made the object of your meeting at Newport.

I am much interested in the subject of the uses of aluminum bronze, a subject with which I have been occupied for nearly thirty years past. I was sent to England in 1859 by Mr. Sainte Claire Deville to take part in the first manufacture of aluminum bronze at Washington, near Newcastle, in the house of Bell Brothers, under the direction of one of the Bell brothers, a metallurgist well known to you to-day as Sir Lowthian Bell. As far back as 1860 they commenced the manufacture of aluminum and aluminum bronze, and used it for several industrial purposes.

Mr. John Percy, in England, and Mr. Debray, in France, have studied the alloys of aluminum and copper, and have noted some remarkable peculiarities. To Messrs. Paul Morin and Lechatelier is due the credit of having sought out the most various applications and the most precise particulars as to the mode of working aluminum bronze. All experiments in the employment of aluminum bronze at that time were crowned with success as to the material results obtained, but the great cost of the metal (15 francs the kilo) prevented the efforts for popularizing the use of aluminum from bearing fruit.

The bronze aluminum was obtained by adding to melted copper a certain percentage of aluminum, its price depending then on the price of that metal. The method of reducing the aluminum invented by the illustrious Wöhler and adopted by Sainte Claire Deville in his remarkable creation of the industrial working of aluminum, could not produce this metal at a sufficiently low price so that its alloys with copper, notwithstanding their remarkable qualities, could enter into the grand industries and be put in competition with ordinary bronzes.

* Translated by Lieutenant D. H. Mahan.

Every kind of work in which the special qualities indicated in aluminum bronze would be required has been undertaken by Paul Morin, from the most delicate objects of the goldsmith's art, secular and religious, to the most diverse pieces of machinery, shaft bearings, slide valves, props of locomotive cabs, etc., etc.—all, even pieces of artillery, have been made and tried by Paul Morin. In fact, early in 1860 a small mountain howitzer in aluminum bronze was cast at the foundry of Nanterre by Paul Morin, and I find in a letter from him, dated April 6, 1860, the following passage: "The cannon has been cast. Before delivering it at the artillery depot where it is going to be tried we have polished it and have cut off the sinking head. The metal appears very perfect and is of an excellent quality notwithstanding the numerous remeltings previously undergone."

It would be very interesting to know the conclusions of the Board of Artillery after the experiments to which the cannon was submitted, but the report has been kept secret, and we have only been told that the results obtained after extreme trial were very interesting and satisfactory.

Why then, you ask, have they not pursued the experiments, since such good results were obtained? I cannot say, but I think that the high price of aluminum bronze was one of the principal reasons that prevented experiments with pieces of a greater calibre; they were without doubt afraid to spend too much in experimenting with a metal all the qualities of which were not yet well known at that time. In fact, one was not then very certain that these aluminum bronzes would always present the same qualities whilst working under the same conditions. There were often sensible differences, due to hammering or rolling—sometimes they blamed the copper, sometimes the aluminum for being the cause of the bad results obtained. It was only after numerous experiments made at the laboratory of the foundry for aluminum at Washington, and by Mr. Paul Morin at the foundry of Nanterre, that the conviction was arrived at that the qualityof the copper played a preponderating part, and that if it was desired to obtain to a certainty aluminum bronzes of good quality, it was necessary to employ copper from Lake Superior exclusively, or the pure copper furnished from galvanic depots. In fact, many manufacturers have found that the trial of a copper for making aluminum bronze was the best proof of the copper. If the bronze obtained was of good quality, they were then sure that the copper tried could be employed and, notwithstanding what was done to it, it would give good results. These are, I think, the principal reasons why the trials of aluminum were not pursued in the construction of cannon. It is also necessary to add that at this epoch commenced the era of iron and steel for weapons of war.

I like to think that, after having waited for more than a quarter of a century, I shall see the era of aluminum bronze arise; regretting only that Sainte Claire Deville, Paul Morin, and Lechatelier are no longer here to see the realisation of their works and hopes.

I have on this account read with great interest the remarkable work of Mr. Alfred Cowles on the employment of aluminum bronze at 10 per cent for the pieces of artillery of large calibre, and on the superior results that they have a

right to expect in regard to the endurance of the pieces, their resistance, and the economy of their production. My studies do not permit me to discuss with sufficient authority the technical questions arising as to the employment for great guns of aluminum bronze. I will ask, however, to call your attention to the homogeneity of aluminum bronze, which should not be considered as an alloy, but as a well known veritable combination. The enormous quantity of heat which is disengaged when they add the aluminum to the copper proves it superabundantly.

Whatever be the dimensions of the cast pieces, they can be more or less successful as regards the casting; but as for the quality of the metal, it is the same in whatever part of the mass it may be—this is an important point.

With aluminum bronze there is no fear of the liquation that takes place in ordinary cannon bronze, and thus the sinking head can be much smaller. In making comparisons with iron and steel it must not be forgotten that aluminum bronze is a veritable combination, a metal of a composition better defined and infinitely more stable than even steel itself, completely free from the molecular changes which so often alter pieces of steel in their primitive qualities after having accomplished a certain work. This tendency to crystallization that steel subjected to repeated shocks possesses, and which renders ruptures possible and always to be feared, will be much less to be dreaded with aluminum bronze.

I recall having used some special pieces of 10 per cent aluminum bronze for a nail-making machine; these pieces received several hundred blows a minute, and have stood the hammering admirably, whilst the same pieces in a special quality of steel, employed before these, were rendered useless in five or six days' work.

The difference in price can no longer be quoted in favor of steel, since, when one recognizes the necessity of abandoning cast-steel guns and the making of guns of many pieces, in this instance the first cost of the metal employed is nothing in comparison with that of the metal worked and finished. With aluminum bronze they will have all the qualities of the built-up gun without having excessive hand-work; moreover, in case of failure the material employed is not lost and can be utilized for a new casting. Those who have worked much in aluminum bronze know that successive castings, far from injuring, improve its qualities.

I can then only confirm the opinion enunciated by Mr. Alfred Cowles, knowing that, if it has been recognized that a "built-up gun" in steel is preferable to a cast-steel gun or an ordinary bronze gun, it does not follow that the built-up gun must necessarily be superior to the aluminum bronze gun cast and treated under conditions which give to the metal its maximum resistance and elasticity.

With Mr. Alfred Cowles, I should say that a cast gun in aluminum bronze can present all the advantages of a built-up gun in steel without its disadvantages. Already there is much interest manifested in France over the question of aluminum bronze since the electric furnace of Messrs. Cowles Brothers permits the production of it at a cheap rate unhoped for even by the practical men interested in aluminum.

The scientific men who are occupied in the construction of pieces of artillery will be the first to employ aluminum bronze as soon as the production of the metal by the Cowles process is an accomplished fact in our country; the customs rates are so high at present as almost to amount to prohibition (5 francs the kilo for aluminum bronze).

In the near future it will not only be for weapons of war that aluminum bronze will present great advantages. The constructors of machines in general, amongst others those requiring great speed, such as for running dynamos directly, will find in the employment of aluminum bronze, on account of its tenacity, its coefficient of elasticity, and its feeble density, the means of solving some mechanical problems up to the present time remaining unsolved.

In summing up that which concerns the application of aluminum bronze to *heavy guns*, permit me, gentlemen, to repeat to you what my dear master and friend Henri Sainte Claire Deville said: "Il ne faut pas faire d'hypothèse, quand on peut faire l'expérience"; or in other words, make a gun in aluminum bronze and try it. I beg you, gentlemen, to excuse this letter, which will not shed much light on the subject; but I desire only that my experience, feeble though it may be, may sustain the proposed plans of application by Messrs. Cowles of one of the products of their remarkable discovery, "the electric metallurgy," which opens a new era for the industries and activity of nations. Accept, gentlemen, the expression of my most sincere respect.

HENRI BRIVET, *Civil Engineer*,
Late director of the Aluminum Foundries at Washington, Eng., and of Salindres, France.

Mr. GEORGE ALLAN, C. E.*—I have the honor to thank you for your copy of the paper read by Mr. Alfred H. Cowles before the members of the Institute on the 27th October last, on the subject of aluminum bronze for heavy guns.

In England, the improvement of steel to be used in the manufacture of guns has, in the last year or two particularly, had special attention directed to it, and there can be no doubt that the investigations already made, and which are still going on, will result in the improvement of gun steel as well as in the mode of gun construction. The English Government specification for gun steel has been recently revised, and under the tempered tests there is now required a yielding point not less than 22 tons and not more than 33 tons, and a breaking strain not less than 35 tons and not more than 45 tons per square inch. The influence of determinate quantities of carbon and manganese in the steel has become better known, and it is now expected that the addition of aluminum will give a higher yielding point as well as a higher breaking strain.

Experimentally treated with aluminum, steel has already been produced in England having its yielding point as high as 27 tons and its breaking point 37 tons, with 60 per cent elongation in 2 inches. This is, therefore, a very decided advance. Still, in my judgment, the high qualities developed in the aluminum bronze manufactured by the Cowles Company appear to promise it ere long the first place among metals for the manufacture of guns. Its elastic

* Of the firm of George Allan & Co., civil and consulting engineers, London, England.

limit and its breaking strain are each of them about 25 per cent higher than in steel. It casts well, and when hot works splendidly under the hammer. It is perfectly malleable at red heat, and rolls beautifully into plates and sheets at a high heat. With a metal of this character and possessing such properties, I am quite of Mr. Cowles' opinion that a solid gun of aluminum bronze would be decidedly superior to a built-up gun of any other metal.

As the destruction of all guns is chiefly due to excessive erosion, the same would equally apply to those of aluminum bronze ; but I am disposed to believe that the unctuous character of the metal and its softening property under tempering, coupled with its known hardness, would ensure a greater immunity from erosion than that which is possessed by steel liners. This, however, is a point easily determined, and if a liner of steel was found to be desirable, that modification would not, in my judgment, militate in the slightest degree against the otherwise solid construction of the gun.

Up to the present time, comparatively little has been known about aluminum bronze as a metal—its price hitherto having been prohibitory to its use—but the Cowles' production of it now on a commercial scale, and at a price that permits of its use in competition with other alloys, has given quite an impetus to its application in every direction in England. I have given attention to it for the past two years, and know of many admirable results obtained by it for important uses, notably the construction of torpedoes in their most important parts, the casting and forging of which has conclusively proven to my mind the perfect suitability of the metal for guns and its capability to work admirably under every operation throughout their construction.

The subject is deserving of the highest consideration of all governments, and coming from your Government—as the metal itself does from your countrymen—the proven success of it for guns would be not the least of the many benefits which your country has already conferred upon the Old World.

JAMES E. HOWARD, C. E.*—In response to your kind invitation to take part in the discussion of Mr. A. H. Cowles' interesting paper on aluminum bronze for heavy guns, I regret that I am in possession of so few data bearing upon the subject.

The Messrs. Cowles have produced some bronzes of great value for many useful purposes, of which it is a pleasure to testify; the fitness, however, of aluminum bronze for the purpose of heavy gun construction appears to be at present somewhat conjectural. The proper metal for this purpose is obviously that which best fulfills all the requirements of the case; therefore to regard aluminum bronze as a suitable metal for gun construction, it must be proven equal or superior to competing metals, and for this there seems to be insufficient evidence.

It will not be understood that in entertaining doubts as to its use in this restricted application, that its merits in other directions are not fully recognized. Any metal which aspires to be used in guns must be a successful competitor

* Expert in charge of testing machine, Watertown Arsenal, Mass.

with steel, a metal which has a very wide range of useful properties. Steel in its worked condition may have a tensile strength ranging between 50,000 pounds per square inch and upwards of 300,000 pounds per square inch, an elastic limit of from 50 per cent up to nearly 100 per cent of its tensile strength, with hardness and ductility according to its chemical composition and mechanical treatment, a high modulus of elasticity, and comparatively low coefficient of expansion by heat, and be capable of acquiring extraordinary combinations of a number of these physical properties. Where the question of strength is paramount it can hardly be said that steel has a rival. The process of manufacture is well understood, and, subject to present methods of inspection, uncertainties are reduced to a minimum. These remarks refer to steel as it is used in the forgings for the modern type of built-up guns.

There appears to be a lack of knowledge of the strength of aluminum bronze in such sized masses as are required for guns, the tests of the metal having for the most part been from small pieces prepared under conditions dissimilar to those which would probably be experienced in gun construction.

It is not known that difficulties met in the casting of large masses of iron and steel would be less in the case of bronze; whether unsoundness of metal, liquation, alloys of different composition in the same casting, dangerous internal strains, may not continue to be obstacles. The usual benefits of chill-bronze castings may not be realized in large masses.

The methods suggested for the subsequent treatment of bronze castings appear to be also applicable to steel castings, if it were desirable to employ them. It is not known whether it is practicable to obtain a satisfactory system of internal strains during the cooling of a large bronze casting, and experiments show that certain cold treatment, such as mandreling, is confined in its direct effects to a comparatively narrow zone of metal, at least in the case of steel. Meagre as our information is concerning the properties of large bronze castings, we are hardly any better prepared to consider the subject of forged and rolled bronze.

From the experiment cited with the hot bronze bar, no superiority over steel is shown, for the latter metal at temperatures from 400° to 600° Fahr. has been found from 10 to 20 per cent stronger than at atmospheric temperatures.

Commander GOODRICH.—I regret extremely that official circumstances prevented my being present at the reading of the paper and taking part in the discussion. It is impossible for me to do full justice to the subject, but as a very imperfect verbal report of the lecture shows that the writer questions the value of oil-tempering and quotes Howard's results, I think it well to point out that the logical conclusion of the argument is entirely against the solid gun, cast on the Rodman principle. It is evidently better to reduce the zones of initial tension by dividing the wall of the gun into concentric rings, thus minimizing the alleged ill effects. This is the practice the world over—a practice based upon experiments on a colossal scale and justified by actual service. We cannot afford to cut adrift from present methods until something better is to be had, something not *in nubibus* but *in re*. We want not good guns merely,

but the *best* guns. Our readiness to change existing modes of fabrication is subject to this single condition, that the superiority of the gun, either as to life or cost, is demonstrated beyond cavil. It is for us to abide by definite results and not accept the burden of proving the new inventions to be worthless.

The following letters pertaining to the discussion were received and read by the Secretary:

15 Bedford Place, Russel Square,
London, W. C., *November* 18, 1887.

Lieutenant Chas. R. Miles,
Secretary U. S. Naval Institute, Annapolis, Md., U. S. A.

Dear Sir:—In accordance with the suggestion contained in letter covering some copies of the paper of Mr. Alfred H. Cowles on "Aluminum Bronze for Heavy Guns," I have laid the letter before some of the gun men, scientists, and engineers in Europe having special knowledge of the qualities of metal for guns, and presume you will hear from some of them in time for the Newport Branch meeting. In response to the receipt of your letter and Mr. Cowles' paper, Professor James Dewar, F. R. S., Professor of Chemistry, University of Cambridge, writes me as follows, in referring to Mr. Cowles' paper: "So far I regard the results as most important and very promising. I have a little difficulty in expressing any opinion on the matter at the present time, seeing that I may have to investigate the matter with the object of acquiring information for a Government."

I also enclose herewith a letter from Sir Wm. Thomson, F. R. S., F. G. S., etc., in response to the receipt from me of your letter of invitation and Mr. Cowles' paper—which, from its source, is of interest in the premises.

I am, dear sir, yours faithfully,
Ben. M. Plumb.

The University, Glasgow, *November* 18, 1887.

Dear Mr. Plumb:—I have read Mr. Cowles' paper with great interest, and it certainly seems to me that the results are very promising in respect to the value of the aluminum alloys made by his electrical process. I do not, however, feel that I have enough of knowledge of the practical questions involved in the application to gunmaking to be able to give information or express any opinion on the subject in the adjourned discussion on Mr. Cowles' paper. I am very glad to hear that the factory at Stoke-on-Trent is now nearly ready to commence operations, and shall look forward with much interest to the results.

Yours truly,
William Thomson.

New York Arsenal, Governor's Island,
New York Harbor, *January* 30, 1888.

Professor C. E. Munroe,
Corresponding Secretary, U. S. Naval Institute, Newport, R. I.

Sir:—As a matter of interest to those who may be present at the meeting of

your Institute on the 1st proximo, I send you to-day by mail a vent piece of aluminum bronze that has been used by the Ordnance Department in a 3.2-inch B. L. rifle.

The metal of which this bouching is made was obtained from the Cowles Electric Smelting and Aluminum Company; with it fifty-six (56) rounds were fired, the powder charge weighing 3.75 pounds and the projectile 13 pounds.*

The action of the gas in passing through the vent was from front to rear, the cut at the inner orifice being towards the muzzle.

This vent piece is not submitted as an indication of what may be looked for as the action of the powder gas in the *bore* of a gun of aluminum bronze. It is known that vent bouchings of steel have been found to eat away rapidly, held to be due to the combustion of the metal; still the erosions in the chamber of our steel field gun have not, after 2000 rounds, been sufficient to render the piece unserviceable.

The bouching of aluminum bronze was tried to determine whether that metal might not prove satisfactory as a substitute for copper.

Will you be kind enough to have the vent piece returned to me after the meeting?

Very respectfully, your obedient servant,

A. MORDECAI,

Lieutenant-Colonel, Ordnance Department, U. S. A.

* The bouching referred to showed considerable erosion, a channel about one sixteenth of an inch in depth and an eighth of an inch in width extending in a spiral direction around the vent for a length of about two inches. The inner end of the bouching had a fissure extending entirely through one wall, a sixteenth of an inch wide and of slightly greater depth.—C. E. M.

PROFESSIONAL NOTES.

SUBMARINE BOATS.*

By G. W. Hovgaard.

[Reviewed by Lieutenant Wm. W. Kimball, U. S. Navy.]

Lieutenant Hovgaard's book is particularly interesting just at present, appearing as it does at a time when the Navy Department advertises for the construction, by contract, of a submarine boat for the U. S. Navy;† when the report of the Hon. Secretary accentuates the difficulties in the way of successfully employing unprotected torpedo boats, and when the interest taken in the late exhibitions of Mr. Nordenfelt's boats is an indication that the whole question of submarine navigation is at last to receive a little common sense consideration. It is quite possible that the efforts of the Department to obtain a practical vessel will result only in the bringing out of a partially successful design which, like some of its predecessors, will be subjected to trial, like them will be praised for its faults, condemned for its virtues, and then passed on to the scrap heap; but the probability that some slight advance in the curiously delayed development of the submarine boat will soon be made is quite cheering, and we of the United States, with no coast defense and no immediate prospect of having one, may congratulate ourselves that we are attempting to move in the right direction as we read Mr. Hovgaard's conclusions on page 9 *et seq.*

"What then will be the result of the extended application of such boats in the above suggested directions?"

"The safety of otherwise defenseless commercial seaports will be immensely increased. Blockades cannot be carried out effectively."

"The value of thick armor, heavy ordnance, and big sized vessels will under certain circumstances be diminished."

"The sea will more than ever form a barrier difficult and dangerous to pass for an army." . . . . .

"To defend all seaport towns effectively by means of forts and armored vessels is next to an impossibility, but the submarine boat, if properly developed, affords a cheap and powerful weapon against the excesses of modern warfare."

In the chapter on the strategical value of submarine boats the author states his case clearly and well; but, from the fact that the coast conditions of Denmark and England are so different from ours, he has not accentuated a feature that is very valuable on this side of the Atlantic, *i. e.* the use of submarine boats as outlying pickets which could not be readily driven in, and which would be difficult to discover and impossible to locate after discovery. It is evident that a submarine boat lying at anchor on the surface should be able to make the spars and upper works of an approaching ship before she herself was discovered; and if she then hove down to the covered plane and showed nothing

* Published by E. & F. N. Spon, 125 Strand, London; 35 Murray Street, New York.

† Circular of requirements issued by the Secretary of the Navy is reprinted on pp. 253-7 of present number.

but the tops of her camera lucida tube and chimney, or hove down below the surface altogether, easing up for an occasional look at the enemy, she would not be made out till close aboard, while all the time she would know the movements of the ship and be always ready to slip and strike as conditions should determine.

The part of the book devoted to the history and development of the submarine boat gives us a very good general idea of the subject, but Mr. Hovgaard would doubtless have made a more complete résumé of the earlier developments and experiences had he been in possession of the writings of Barber.

The chapter on construction is exceedingly interesting and instructive, and is in itself the best of evidence of the conscientious work done during the author's three years course at Greenwich.

Naturally the type of vessel advocated by Mr. Hovgaard is one adapted for service off the Danish coast and in the neighboring waters—is, in fact, one for a submerging cruiser rather than for a submarine boat; and just as naturally the vessel is devised in accordance with what may be called the European in contradistinction to the American idea, as regards the method of obtaining submersion; in other words, the vessel is devised as a *sinking* rather than as a *diving* one.

Why the method of submerging a boat on an even keel is so attractive in Europe one fails to understand, unless there has been an application of experiences gained in the old Plongeur to conditions entirely different from those that applied in her trials. She was designed to, and at first did, manœuvre submerged without buoyancy, was constructed with too little regard to longitudinal metacentric height, and was furnished with very inadequate horizontal rudders both as regards surface and mechanism; consequently, the device of hand-worked, vertical-acting propellers, which the boat was not originally intended to carry, was put in play to control the wide oscillations in the vertical plane that were developed in the first trials, by pulling down against buoyancy. But even in the Plongeur experience showed "that it was necessary to improve the (horizontal) rudder mechanism and to increase the area of the rudders, *as they were found to afford the best means of keeping a certain depth* (while under way)."

In the later American boats it has been shown that there is no difficulty in so arranging the longitudinal metacentric height, the amount of normal buoyancy, and the horizontal rudder area, that dives can readily and safely be made by *steering* down, and that the boats can be held in any selected horizontal plane and run there by depth gauge by the use of the horizontal rudders alone. This being the case, it is difficult to comprehend why Mr. Hovgaard would, and Mr. Nordenfelt does, abandon the idea of diving, relegate the horizontal rudders to the secondary use of automatically keeping the boat on an even keel, and depend on the down hand propellers for submersion under all conditions; a method of submersion almost as dangerous and impracticable as the one of changing volume by the thrusting out and hauling in of cylinders. In the exhibitions of the Nordenfelt boats great stress is laid upon the fact that they are always buoyant; but the bearing of the statement of this fact is not very apparent when one remembers that this feature has been prominent in submarine boats for at least a century, and that much less buoyancy can be pulled down by small down haul propellers working perpendicularly to the whole horizontal longitudinal section of the boat, than can be pushed down an incline by the main propellers working against a cross section. Of course the same reasoning, proved by practice, applies to the aid given to the normal buoyancy in rising.

In this connection it may be stated that for manœuvring purposes pure and simple, the adjustable float side wheels of Hunter are more attractive than any arrangement of propellers; for the capability they give of applying the whole motive power in any possible direction that may be chosen, and of thus rendering unnecessary all rudders and propellers, horizontal and vertical, is very

desirable ; but these wheels are not practicable in their present stage of development because they are so very wasteful of power, and because their bulk and position are so objectionable.

The most valuable quality of a sinking boat is that she is not quite so liable to stick her nose in the mud of the bottom when dropping down, as is a diving boat when steering down in a locality in which the depth of water is entirely unknown and happens to be less than that provided for by the automatic depth check ; but this possible advantage in the sinking boat is more than counterbalanced by the facts that she is much slower in getting down or up, is more limited in the amount of buoyancy she can carry, is very difficult to keep in the exact trim she requires, and is powerless to apply her main power to clear herself from the bottom when she strikes it.

The mechanical down haul by propellers or other devices is, to be sure, a most important feature, since without it a boat could not stop and hold herself at any required depth, and it will be noticed that such a device is required in the boat outlined by the Department's circular ; but it will also be noticed that the circular requires that the horizontal rudders, or their equivalent, shall be used in steering up and down, since the boat "should be able to make very quickly a change of direction of at least 10° in the vertical plane."

If we compare two boats exactly similar in displacement, lines, total power developed, and with buoyancies measured by the power applied through down haul propellers, the one a sinking and the other a diving boat, it will be seen that the former while making a run under the surface must always work her down hauls, must limit her buoyancy to the amount that these can take down with the power that can be spared from propulsion work, and must be very slow in changing depth ; while the latter can throw her vertical propellers out of gear and thus utilize all her power for propulsion, can take down all the buoyancy that her speed and horizontal rudder surface can control, can hold down when stopped an amount measured by her total power applied to the down hauls, and can dive and rise quickly ; which last would seem to be an important matter in view of the fact that when approaching to the attack in the covered plane, a submarine boat might find it extremely desirable to quickly dive, pass under the enemy's keel, and give him a shot in the bottom, especially if he had nets out.

The boat outlined in the Department's circular could be manœuvred as a sinking, although it would be essentially a diving one.

Mr. Hovgaard's ideas on special fittings and appliances are extremely well thought out, and his remarks on pumping power and on the difficulty in the way of blowing out large bulks of water are particularly valuable.

The method of carrying a boat for saving the crew in case of disaster, as in the old Plongeur, is not particularly interesting to us in America, where, for the present at least, only submarine *boats* and not the *cruisers* are under consideration.

The author's reasons for adopting the section he does are sound, but it must be borne in mind that he is considering a sinking vessel, and consequently after insuring trim he can afford to decrease the amount of metacentric height necessary in a diving one, for the sake of getting good stowage room with small draft. For a diving boat the sections, if they be not circles, should of course have their larger dimensions vertical rather than horizontal.

On the question of motive power, which is, after all, the most important one, since if sufficient surface speed and radius of action can be secured in a submarine boat, the other necessary details can be satisfactorily arranged, the author gives us most interesting information. Like Mr. Nordenfelt he advocates a coal-fired steam boiler as the source of power and for surface work, but unlike that gentleman, he chooses to store electricity rather than heat for the submerged runs, and gives data for expected results from storage cells. Since the cells failed so signally in the Peacemaker they have been rather out of favor on this side of the Atlantic, but the difficulties then encountered from leakage, lack of power for weight carried, length of time necessary for

charging, etc., etc., would, under the author's showing, be materially lessened in applying the cells to-day. Still, the great objection to Mr. Hovgaard's method of obtaining power, that of using two very different kinds of motors, remains; an objection avoided by Mr. Nordenfelt through the use of stored heat to make steam for under water work, at the expense of applying a cumbersome and extremely slow method of storing power.

In this country the favorite power is steam, derived from a petroleum-fired boiler for surface and covered runs, and from a Honigman soda or other chemical heat producer for submerged work, always applied by the same engines. The attractiveness of liquid fuel is especially accentuated in submarine boats, in which the available stowage spaces are not well adapted for coal bunkers, and in which convenience in firing and in dowsing fires is so important. With the combination of the petroleum-fired and soda-heated boilers, all that is necessary to do when diving is to close the fuel valve, open the exhaust into the soda side of the Honigman, and put down the horizontal helm. The first of the dive would be made on the steam already in the steam space of the main boiler, and when the pressure there was, by the work of the engines, reduced below that on the steam side of the Honigman, the balance valve would open and steam from this soda heater would pass to the main boiler steam space for engine supply; and thus the submerged run could continue, as the soda made steam, till the saturation point was reached. At the end of a dive, long or short, the fire would be lighted under the main boiler, and as the pressure in this ran up, the Honigman would be shut off and the exhaust turned overboard, while the surplus moisture in the soda would at once begin to be driven off by heat derived from the main boiler fires.

After this method of applying steam, the petroleum engine is a close second in favor, and is very promising as lately improved by Holland in developing good power up to a certain limit, in its feature of requiring no boiler or any fire outside the cylinders, in the fact that the compressed air stores for feeding the engine when submerged can always be drawn on for ventilation, and for the reason that these stores can be so readily renewed after making a submerged run. The space occupied by the compressed air for a petroleum engine is perhaps larger, for equal power developed, than that used by a soda boiler; but on the other hand it can be distributed about the boat in pipes in such a way as to occupy comparatively little of the space available for crew and armament. The prime objection to petroleum engines is that, so far as developed, they cannot give economical results in boats of more than thirty or forty tons displacement.

The following figures, from a design now under consideration by American builders, for a petroleum motor submarine boat intended for hoisting inboard, like a third-class torpedo boat, illustrate the attractiveness of the type: Length, 40 feet; diameter, 5 feet; shape, spindle of revolution; displacement, 15½ tons; weight without water ballast, 12½ tons; maximum surface speed, 14⅓ knots; maximum submerged speed, 18 knots; fuel endurance at 8 knots surface, 27 to 33 hours; total submerged run, 4¼ hours, of which ¼ hour at 18 knots and 4 hours at 12 knots; crew, 2 men; armament, one 8″ torpedo gun, four 100 lb. G. C. torpedoes; range through water, 150 yards; range through air, ½ mile.

Of some six or eight other proposed boats, the greater number lack speed, not because it cannot be easily gotten, but because builders are cautious about guaranteeing it.

From a point of view determined by what has lately been done, the prospect of obtaining a serviceable boat is not very good. In the United States the Holland boats have lacked speed endurance and carrying capacity, and the Peacemaker is altogether inadequate, being interesting only as an illustration of the use of a simple soda boiler. In Europe the Goubet boats lack power in all directions, and the Nordenfelts are apparently failures in all respects save surface speed and fuel endurance, as their trials show nothing of practical use.

In an exhibition of one of these boats given last month the main features accentuated by the exhibitors were that the boat awash was more difficult to make out than another boat of greater freeboard—a fact that would seem to need no very extensive proof—and that she was always buoyant, a property that, as has been shown, is common to all submarine boats worthy of the name, and which she possesses in a much less degree than she might were she constructed on common sense principles for real submerged work, for which she showed less capacity than the small American boats. The showing of submerging qualities consisted in hauling the boat down to the bottom of a dock by means of her down haul propellers, and then allowing her to rise by her own small buoyancy, thus exhibiting the application of a general principle that could have been just as well shown, and with just as much bearing on real submarine boat work, by pushing a cork under the surface of the water and then allowing it to bob up.

On the other hand, in looking over the field of possibilities for the immediate future it is apparent that there are plenty of practical devices extant to make a submarine boat successful, plenty of experience to apply them, and plenty of money to pay the expenses of construction ; and therefore it only remains to be seen whether or not the owners of the devices, experience, and money will have the wisdom to comprehend that in combining to give the Navy Department the boat it requires they will be working to their own advantage as well to that of the Government.

Even if the Department fail in its first attempt to obtain a practical construction of the kind, the submarine boat, as such, must soon appear as a factor in naval warfare—for just as rapidity and range of aimed fire have forced the use of earth cover ashore, so will the same causes force the use of water cover afloat—and unless "we, the people of the United States," choose to continue to be as stupid as we have been for the last score of years concerning everything that floats, we are in our own interests bound to lead in its development. When it comes it will not, like every new warlike device conceived in the brain of a cranky inventor, "entirely revolutionize warfare," but it will assume the well defined place and duties awaiting it—place and duties that will urgently require to be filled and done if there is to be even a faint attempt at placing this country in a condition of partial defense.

SUBMARINE TORPEDO BOAT FOR THE UNITED STATES NAVY.

[Reprint of circular showing the general requirements desired to be fulfilled in the design and trial of a steel submarine torpedo boat for the United States Navy.]

NAVY DEPARTMENT,
WASHINGTON, D. C., *November* 26, 1887.

Under authority conferred by the act of Congress, entitled "An Act making appropriations for the Naval Service for the fiscal year ending June 30, 1888, and for other purposes," approved March 3, 1887, to which reference is made as a part of this advertisement, sealed proposals are hereby invited and will be received at this Department until 12 o'clock noon, on the first day of March, 1888, for the construction, by contract, of one submarine torpedo boat, complete, with torpedo appendages—such vessel to be of the best and most modern design ; to be constructed of steel, of domestic manufacture, having a tensile strength of not less than 60,000 pounds per square inch and an elongation in eight inches of not less than 25 per cent, and to have the highest attainable speed.

For information as to the conditions desired by the Department, reference is made to the "circular showing the general requirements desired to be fulfilled in the design and performance of a steel submarine torpedo boat," approved by the Secretary of the Navy, copies of which can be obtained on application to the Bureau of Ordnance, Navy Department.

Each proposal must be accompanied by drawings and specifications of the vessel which the bidder proposes to build. The drawings must be drawn correctly to a convenient scale, and must show clearly all the essential requisites of the vessel. The space and weight allowed for torpedoes and their appendages must also be shown in the design, and the fittings for the same are to be furnished or installed by the contractor.

A statement, in detail, of the weights in the vessel and their distribution, and full particulars and explanation concerning the kind, power, and economy of the engines, power generators, and propelling devices, and all other mechanism, must accompany the proposal.

In order that the Department may be prepared to act intelligently in making a selection, it must be clearly shown by the drawings, specifications, and statement or statements accompanying the proposal, that the displacement and stability are sufficient, and that the balance of qualities is such that everything will be carried properly and safely; and such additional information must be included as may be necessary to enable the Department to readily determine the character of the proposed vessel and the correctness of the calculations upon which the design is based.

The contractor must furnish, at his own expense, all working drawings necessary to the complete construction of the vessel, and the expense of all trials, before final acceptance of the vessel under the contract, must also be borne by the contractor.

Proposals must be made in accordance with forms which will be furnished on application to the Bureau of Ordnance, and must state the time within which the bidder will complete, for delivery, the vessel which he proposes to construct.

Each proposal must be accompanied by a certified check, payable to the order of the Secretary of the Navy, for an amount equal to five per cent of the bid. The check received from the successful bidder will be returned to him on his entering into a formal contract for the due performance of the work and giving bond for the same, with security to the satisfaction of the Secretary of the Navy, in a penal sum equal to sixty per cent of the amount of his bid; but in case he shall fail to enter into such contract and to give such bond within thirty days after notice of the acceptance of his proposal, the check accompanying such proposal shall become the property of the United States.

All checks accompanying proposals which are not accepted will be returned immediately after the award shall have been made.

Payments under the contract will be made in five equal instalments, as the work progresses, upon bills duly certified. The last payment will be made upon the acceptance of the boat after trial. Twenty-five per cent of each instalment will be reserved until the final acceptance of the boat by the Department.

Proposals must be made in duplicate, inclosed in envelopes marked "Proposals for a submarine torpedo boat," and addressed to the Secretary of the Navy, Navy Department, Washington, D. C.

The Secretary of the Navy reserves the right to reject any or all bids, as, in his judgment, the interests of the Government may require.

(Signed) WILLIAM C. WHITNEY,
Secretary of the Navy.

GENERAL REQUIREMENTS.

The design for a submarine or diving boat, to be acceptable to the Department, should show the manner in which it is proposed the vessel shall be manœuvred under all conditions, but more especially how she is to be brought into action from a distance.

The most desirable qualities to be possessed by such a vessel while approaching a hostile ship under way, are speed, certainty of direction, invisibility, and safety from the enemy's fire; the design and description should plainly show the amount of each of these qualities that the boat would possess, and the advantage that results from diminishing any one for the purpose of increasing any other.

The Department has no knowledge of any method by which certainty of approach to an object constantly moving and constantly changing its direction of motion can be secured, unless the object is kept constantly in view or lost sight of for brief intervals only; consequently, if no novel method for insuring certainty of approach (when submerged) be devised, a design, showing, at the expense of invisibility, great speed for use outside the range of effective hostile fire would be desirable; providing always that submergence to a safety depth can be quickly secured, and certainty of approach still be retained when coming within the danger zone. Within the danger zone a part of the speed of approach may be given up for the sake of obtaining water cover, provided certainty of approach can be still maintained until the object of attack is so near that this certainty is virtually secure even when the boat is deeply submerged for the purpose of obtaining total invisibility or for delivering the attack at a vulnerable point.

The following definitions are adopted for convenience in describing the conditions under which submarine boats generally move:

"*Surface*"—*i. e.* with freeboard or awash.

"*Covered*"—*i. e.* protected by at least three feet of water over the highest point of the shell, not necessarily cut off from connection with the atmosphere, and furnishing a view of the object of attack through air.

"*Submerged*"—*i. e.* at any safe depth, cut off from communication with the atmosphere, and affording no view of the object of attack other than one through water.

Any boat not designed for running "submerged" cannot be considered submarine; and she should be able to run in at least one of the other ways mentioned in order to be satisfactorily effective.

The features essential to the usefulness of a submarine boat designed for offensive warlike purposes are in general terms held to be:

Great safety, facility and certainty of action when "submerged," fair speed when "covered," good speed when running on the "surface," a fair endurance of power and stores, great ease of manœuvring under all conditions, sufficient stability, great structural strength, and fair power of offense.

The Department would particularize as to these qualities about as follows:

I. *Speed.*—The boat should be capable of making at least fifteen knots per hour when running on the "surface," and at least twelve knots per hour when running "covered." When running "submerged" she should have a mean speed of at least eight knots per hour.

II. *Power endurance.*—She should be able to run for about thirty hours at full power, on the surface or "covered," while at the same time she should maintain at its greatest efficiency the power that is to be used for "submerged" running. When "submerged" she should be capable of running at least two hours at 8 knots mean speed. If intended for "covered" and "submerged" work *only* (without using air draught), she should be capable of running in that condition about thirty hours at full power.

She should carry about ninety hours provisions and water for the crew.

III. *Ease of manœuvring.*—When running on the surface, "covered" or "submerged," the boat should be able, when working at full power, to turn in a circle of a diameter not greater than four times her length, and this without reversing her engines.

If designed to run part of the time on the surface, she should be able to pass from the surface to the covered plane in 30 seconds.

When below the surface, she should be able to make very quickly a minimum change of 10 degrees in direction in the vertical plane.

The conditions necessary for furnishing power for "submerged" runs must at *all* times during the working endurance be maintained at their maximum efficiency and ready for *instant use* until the first "submerged" run is commenced. After the boat has again made communication with the air, the time of renewing that part of the power that was used while "submerged," or re-arranging the conditions for submerged running, which were altered during submergence, should not be longer than twice the period of the submerged run.

While lying still the boat must be able to maintain any desired depth within the limits of safety from crushing pressure upon the shell. It is not considered that this requirement can be fulfilled simply by varying the specific gravity of the boat.

IV. *Stability.*—This quality must be possessed in good measure when the boat is on the "surface"; and when "covered" or "submerged" the stability must in great part depend upon "normal buoyancy"—*i. e.*, a certain amount of buoyancy normally remaining in the boat and never given up, unless it should be necessary to sacrifice buoyancy in order to sink from under an obstruction or to lie upon the bottom for the purpose of conserving power.

The amount of this normal buoyancy and consequent stability must be sufficient to allow the necessary movement of the crew in working the machinery and torpedo appliances while the boat is "submerged" and lying still, but not on the bottom; and it is thought this amount of buoyancy will be more than sufficient for the purpose of successful and convenient navigation when the boat is "submerged" and moving at moderate speeds.

V. *Structural strength.*—The shell should be sufficiently strong to withstand an exterior water pressure due to a submergence of at least 150 feet.

VI. *Power of offense.*—Against any part of the bottom of a ship running at speed the boat must be able to deliver, with reasonable certainty, torpedoes carrying charges equal in minimum effect to 100 pounds of gun-cotton. The mode in which this requirement is to be met is left entirely to the designer; but it is to be remarked that the method which gives the greatest under-water range, with accuracy, will be preferred. Rapidity of rate of delivery, extension of angle through which torpedoes can be delivered, number of torpedoes that can be carried, and effective over-water delivery, are all important factors for determining the power of offense.

Besides the foregoing principal requirements, the boat must be provided with means for the attainment of the following objects: Enabling the commander to see the object of attack when running "covered," and an all-around view should also be provided, if practicable; compensating or otherwise *insuring the accuracy of the compass*, when "submerged," and under all conditions; purifying the air for the crew so as to allow at least 12 hours submersion; keeping the temperature within the boat down to 100 degrees Fahr.; getting away from obstructions—above, below, or lateral; pulling out of mud; automatically preventing a dive below a predetermined depth; preventing the fouling by lines or other obstructions of any working parts exterior to the shell proper; lighting the interior, and for the escape of the crew in case of disaster.

These qualities are expected by the Department both because, in its opinion, they are necessary, and because they have already been attained with more or less success in submarine structures now extant. But as the bids are to be made upon the basis of guaranteed results, bidders are at liberty, in their proposals, to modify or omit, as they may think proper, any of the qualities mentioned herein, always excepting qualities of workmanship and material used in the construction of the hull, engines, power generators, and other mechanism.

Any valuable qualities not enumerated by the Department (which limits itself to pointing out those that appear to be the most useful) will be fully considered and given due weight in deciding upon the design to be adopted.

As the Department does not define the means by which results are to be attained, it will accept no responsibility as to the efficiency of the methods proposed to be used.

Designs must be accompanied by written explanations fully setting forth the operation of the boat and appendages, and stating all the advantages of the proposed vessel.

The bidder to whom the award is made will furnish detailed drawings and specifications of his boat, and the contract will be based on these. They must not differ in any important way from the general design and explanation submitted with the proposal.

QUALITY AND WORKMANSHIP.

All material is to be of the best quality, of domestic manufacture, and subject to the tests and inspection laid down in the appended instructions concerning tests to be applied to steel for use in the construction of the hull and machinery of a torpedo boat, approved by the Secretary of the Navy, July 15, 1887.

The workmanship shall be of the highest class, and subject to the inspection of officers designated for the duty. Such inspectors shall have free access to the works of the builders at all times, for the purpose of witnessing and examining the progress of the vessel and machinery, and they are to be afforded every facility and assistance for inspecting and for ascertaining that the work is done in accordance with the terms of the contract.

GENERAL REMARKS.

Conditions will be inserted in the contract requiring, upon the completion of the boat, trial sufficient to test her efficient operation, and to insure that the contract has been properly performed, and that the guarantees assumed by the contractor have been complied with.

A boat rejected under the contract may have exhibited certain important qualities in a much greater degree than was contemplated by the contract, or she may embody devices and improvements novel and very valuable but not called for by the contract.

In such a case the Department might possibly be disposed to purchase the boat, but such a course will not be pursued unless the advantages to the Department are of the most obvious character.

The Department limits the maximum displacement to two hundred (200) tons when the vessel is "submerged," and it puts the displacement at so large a figure in order that designers may not be hampered in attaining good speeds by lack of space for motors; but it is thought that designs showing about ninety (90) tons displacement will give the best results. No bidder is limited to the submission of a single design, but each is invited to submit as many as he may see fit. Independent drawings and explanations, and a separate proposal for building the vessel shown, must accompany each design.

The foregoing statement of "general requirements" is intended only as suggestive, and as embodying for the benefit of bidders the views of the Department as to what ought to be accomplished by any person assuming to offer a plan for an effective submarine torpedo boat; but the Department is of the opinion that results already attained justify the purchase of a submarine boat though the exact requirements of the circular may not be guaranteed. Bidders are therefore invited to submit their designs even though these may show qualities less desirable or less difficult to attain than those hereinbefore described: they should be careful to state what matters are guaranteed.

All bids will be considered without regard to the residence of the bidder, but the boat must be of domestic manufacture.

No bid will be accepted that does not offer guarantees of results approximating to those stated in this circular, nor unless accompanied by plans justifying, in the opinion of the Department, a reasonable expectation that results guaranteed will be attained.

All other bids will be rejected. (Signed) William C. Whitney,
Secretary of the Navy.

A CONTRIBUTION TO THE MECHANICS OF EXPLOSIONS.*

By E. MACH and J. WENTZEL.

[Translated by Lieutenant KARL ROHRER, U. S. N.]

During the past few years observations have been made in this Institute upon the phenomena attending explosions, some of which appear to us of sufficient importance to warrant special experimental study.

It is known that many explosive bodies, as dynamite, possess certain remarkable peculiarities. An exploding dynamite cartridge, for example, will cause another some distance off to explode through influence;† a behavior which led Abel to his wonderful theory of synchronous vibrations. In our opinion, Berthelot‡ has successfully confuted this theory, notwithstanding the support which Champion and Pellet gave it through their beautiful experiments in detonating nitrogen iodide upon the string of a violoncello through influence by sounding the same string of a similar instrument,§ or detonating nitroglycerin in the focus of a concave mirror through the explosion of nitroxylglycosin in the conjugate focus of a second con-axial concave mirror turned toward the first.‖ These experiments only demonstrate in another way the sensitiveness of these bodies to shock.**

The erosion and pitting which are observed upon metal plates upon which dynamite has been exploded leads Daubrée back to the action of the very dense and highly heated gases of explosion; and he declares, upon the basis of experiments made in conjunction with Sarrau, that these manifestations are exactly similar to those seen upon the surface of meteors which have passed through the air with a velocity of from 20 to 30 km. per second.††

But in the most striking contrast to our mechanical instinct, is the fact that an unconfined dynamite cartridge, when exploded upon a metal plate, breaks a hole through it, or breaks up that part lying immediately under itself into polyhedral fragments, while apparently there is no impediment to the escape of the gases of explosion upwards. We will examine the latter phenomenon more closely and endeavor to lead back to its cause, from which also the explanation of the other mentioned facts will follow.

We have carried on nearly all our experiments with white silver fulminate, a quantity of which, about 5 mg., laid on a visiting card clamped in a horizontal position, unconfined and between two tinfoil electric terminals (Fig. 1), when fired by electricity, blew a hole through the card about the size of the base of the heap of silver fulminate.

* Annalen Phys. Chem. **26**, 628-640; 1885.

† We have made similar experiments to develop explosions through influence, using silver fulminate charges placed in opposite ends of small brass tubes which were corked. The explosion of one charge causes the explosion of the other, and the greater the former is, the longer may be the distance between them.

‡ Berthelot, Sur la Force des Matières Explosives, **1**, 123. Paris, 1883.

§ This experiment, which only shows what was to be expected from the readiness of nitrogen iodide to explode, proves nothing in regard to synchronous vibrations. The period of vibration which might be related to its explosion is, at all events, of entirely different duration from that of a violoncello.

‖ The following experiment which I made many years ago to illustrate a lecture on acoustics, also fails to prove this theory. I used silver fulminate as the influencing body in one focus, and nitrogen iodide as the influenced body in the conjugate focus. One may feel with the hand at one focus the violent impulse produced by the explosion at the other, and it can be optically demonstrated by the Schlieren method that this impulse consists of one undulation without periodicity.

** The explosion of the body through the action of a shock is in itself the most noteworthy point of all, when it is considered that the work of the shock can only raise the temperature of the whole mass imperceptibly. It must be remembered, however, that the whole work is transferred to only a very small part of the whole mass, as in the use of a flint and steel—and certainly vibration plays no rôle here. Only when an explosive body is very near its exploding point may it be exploded through sonorous vibration. In years past I have occasionally brought to ebullition water nearly at the boiling point by exciting to sonorous vibration a glass rod dipped into it.

†† Daubrée, Experimental Geology. German edition. Brunswick, 1880.

Similarly, holes may be made through panes of glass, thin sheets of metal, etc. A wax plate is bent, broken through, or has the under side blown off. A thicker wooden plate shows a perceptible impression in the wake of the point of explosion. If paper is laid upon a table and 5 mg. of silver fulminate is fired upon it, there will be in the wake of the explosion a convex blister. Tinfoil substituted for the paper is torn open upwards. The blister which is formed in these cases may be regarded as the effect of recoil which follows after the great and violent pressure of the paper or tinfoil against the table.* It might be thought that the air would hinder the escape of the suddenly developed gases of explosion and so play a rôle in the premises, but silver fulminate exploded under the bell of an air pump at about 2 mm. pressure of mercury blows a hole through a card just as it does in free air, though the otherwise very powerful report of explosion reduces itself in this case to a very gentle blow of the gases of explosion against the sides of the bell of the air pump.†

The resistance of the air has therefore nothing to do with this phenomenon. The same holds true of the most heterogeneous violent explosions, not being confined to the explosion of silver fulminate, dynamite, or any other explosive body. If pointed tinfoil terminals are secured on a glass plate (Fig. 1) and the points thereof connected by a line of metal powder, the plate then being covered with turpentine and suspended in air, the discharge of a Leyden jar through the terminals will break a hole in the plate between them, or shatter it entirely. The spark of a Leyden jar passing near the wall and through the fluid of a filled glass jar often breaks a hole in the wall. The work of the spark in our experiments was inconsiderable, amounting altogether to about .2 kilogrammeter, of which, naturally, a considerable portion must be reckoned to the spark in the air. If upon the silvered side of an ordinary silvered and varnished mirror such as can be bought in any market, there are placed, a few centimetres apart, the discharge points of a powerful battery of Leyden jars, and the charge of the battery is passed through the silver of the mirror, a hole will be broken in the glass in the wake of each discharge point, as Doorók observed.‡ If the mirror is only silvered and not varnished, the holes will not be made; apparently because of the small mass of silver which is scattered and volatilized.

The difference in velocity with which explosion progresses in powder or unconfined gun-cotton on one hand, or in dynamite and silver fulminate on the other, is very striking. The former bodies burn, if with great rapidity, yet for an appreciable period of time, while the decomposition of the latter requires an exceedingly short time. If a piece of paper is folded and flattened out again, and the seam of the fold strewn with powder, and at intervals along the powder line a small quantity of silver fulminate is placed, then upon ignition at one end the line is seen to burn rapidly, but the reports of the explosion of the silver fulminate heaps are heard distinctly one after the other. The marks left upon the paper indicate clearly the direction *AB* of the propagation of the explosion (Fig. 2), while in the wake of the heaps of fulminate there are holes which it has blown through the paper with marks radiating therefrom in all directions.

All the foregoing peculiar phenomena probably depend upon the great velocity of transmission of explosion, and we will therefore endeavor to prove

* Similar recoil effects may be observed under other circumstances. A large tub filled with water in which a charge of powder was exploded, rose from its support immediately after the explosion and rise of the column of water. In the case of the explosion of a considerable quantity of mercury fulminate in Vienna, about 1856–1858, it is said that the shelving and cupboards lining the walls of the laboratory fell inward.

† The phenomenon is also very pretty as a lecture experiment in acoustics. On this occasion we also repeated the familiar experiment of melting and slowly evaporating gunpowder in a vacuum, proving the truth of the published statements in reference to this experiment. To produce the necessary temperature we made use of the electric current.

‡ Doorók, Wied. Ann. **19**, 323; 1883.

this by a simple experiment.* We place silver fulminate upon two battens, evenly distributing it along their length, and then lay them upon two parallel surfaces *AB* and *CD* (Fig. 3), and between the two we place a plate of glass whose upper surface is covered with lampblack. Igniting the two lines of fulminate simultaneously at opposite ends by electricity, there is produced upon the blackened plate of glass an oblique interference line *EF*, whose angle a with *AB* determines the velocity of propagation of the explosion, if Huygens' principle for the velocity of the sound wave is accepted for that proceeding from the area of explosion. We have, then, $\frac{c}{v} = \sin a$, where c represents the velocity of sound (about 400 m. in the case of the powerful explosions in our experiments), v representing the velocity of propagation of explosion in the silver fulminate. In our experiments we obtained values for v varying from 1700 to 200 m. sec.† Other similar experiments giving the same results we will not cite.

Because of this great velocity of propagation of explosion, a small heap of silver fulminate, a few millimetres in diameter, detonates in an immeasurably short time, and the gases of explosion are of about the same density as the solid body, and have at the same time the high velocity which is given them by the work of explosion. As this last belongs to the order of projectile velocities, it is reasonable to assume that the plate upon which the explosive body rests will in a measure be broken through, because the lower half of the explosive mass supports itself against the upper half, and as both, on the principle of action and reaction, take equal but opposite velocities.

We constructed a small ballistic pendulum out of a T-shaped piece of wood suspended by a needle through the junction of the vertical and horizontal arms (Fig. 4). To the three arms we secured the cards *A*, *B*, and *C*; *C* on the vertical arm serving as pointer. If, by means of suitable electric appliances, we explode 5 mg. of silver fulminate upon *A*, it will be broken through without causing the pendulum to make a perceptible swing. In order to press an equally large hole through the card with a cylindrical punch it was necessary to weight it with 20 kilograms. As about the same force will always be required to tear the card, we can estimate in how short a time the perforation is achieved by explosion, as by the exertion of so great a force no perceptible movement is transferred to the pendulum.‡

We wished by experiment to ascertain an initial point for determining the velocity which is imparted to the particles of the gases of explosion by the work of the explosion, and accomplished it in the following simple manner: To the ends of the horizontal arms of the small pendulum before employed were attached the hemispherical bowls *A* and *B*, made of sheet brass, Fig. 5. *A* was covered with silk paper, to which were pasted tin foil terminals, between the points of which was placed about .02 g. of silver fulminate. Movable weights *E* and *D* on the vertical and horizontal arms serve to secure equilibrium and to regulate the duration of the oscillations. Half the wave of explosion, reckoning from the centre, strikes the whole area of the bowl, but not with sufficient force to pierce it, and so gives the pendulum ample motion. If we let *Q* represent the quantity of motion given to the pendulum by the wave of

*I made this experiment for the first time in the winter of 1880, assisted by Dr. G. Pick. The results were published in a lecture before the Société de Physique de Paris, Séances de la Société, etc. Paris, 1881, **213**.

† Berthelot found the same relative values for the velocity of the propagation of explosion in gaseous mixtures by a more complicated method.

‡ If b represent the distance of the point of perforation from the axis, p the variable force when the card is perforated, θ the moment of inertia of the pendulum, w the attained angular velocity, then we have

$$\frac{b\int_0^t p\,dt}{\theta} = w, \text{ or more simply } t = \frac{w\theta}{bP},$$

where t represents the duration of the piercing, and P the mean force required.

explosion, M the mass, T the time of oscillation, a the distance of the centre of gravity from the axis, b the distance of the point of impact from the axis, g the acceleration of gravity, and α the angle of oscillation, then we have the relation: $Q = \frac{2}{\pi} M \frac{a}{b} g T \sin \frac{\alpha}{2}$. The momentum mv of the explosive mass bears the following relation to Q: Half of mv is in the lower half of the wave of explosion, Fig. 6, which impinges on the inner area of the bowl, and for the vertical components we have, from Fig. 7,

$$Q = \frac{\frac{1}{2} mv \int_0^{\frac{\pi}{2}} r d\phi \,.\, 2\pi r \sin \phi \,.\, \cos \phi}{2 r^2 \pi} = \frac{1}{4} mv,$$

if it is assumed that the whole motion of the lower half of the wave of explosion is absorbed by the bowl. If a reflection of the wave without weakening is assumed, then $Q = \frac{1}{2} mv$. The velocity v lies then, at all events, between the limits $\frac{4Q}{m}$ and $\frac{2Q}{m}$, probably nearer the smaller value.

The limits of velocity are, in our case, between 3500 and 1750 m. sec.* The work of explosion of 1 g. silver fulminate, expressed in gram calories, lies between 1469 and 367 calories, probably nearer the lower limit.†

As, in accordance with what we have shown, the exploding mass in any case receives in a very short time, and while still of great density, a velocity very much higher than the ordinary projectile velocity, therefore the piercing of the underlying plate is no longer unintelligible. In the same way are explained the piercing and breaking up of glass plates by electrical discharges in the foregoing experiments.

The piercing of plates by means of silver fulminate charges directs attention to a kindred phenomenon. As is known, a well defined round hole may be made in a pane of glass by firing a rifle ball through it, and the hole will be little greater in diameter than the ball. We made this experiment and observed that the freely suspended pane of glass was scarcely moved by firing through it. The glass is not shattered because it is not sagged or bent by the impact of the ball, being perforated before the force tending to sag or bend it can be propagated, owing to the smallness of the velocity of propagation of a transverse undulation. The holes made by the balls are funnel shaped, Fig. 8, being of less diameter on the side at which the ball enters, from which the direction of flight of the ball may be positively determined. Exactly the same peculiarities are remarked in the holes made in panes of glass by the electric spark (Doorók) or by silver fulminate. The funnel form of the holes may be explained by considering that from the point of impact there is propagated a longitudinal undulation of great velocity, and that the last parts of it, by virtue of their great excursive velocity, tend to tear away the glass as the particles at the end of a powerfully sonorous column of fluid fly off as drops (Cagniard-Latour, Doorók).

Here we would mention another striking fact which may also depend upon

* The data in our experiments were: M=44.4 g., m=.02 g. (silver fulminate), T=.47 sec., a=8.2 cm., b=12.8 cm. α, varying a little in successive experiments, averaged about 24°.

† We are not familiar with any direct determination of the explosive work of silver fulminate. The explosive work of mercury fulminate, however, practically lies near the lower limit here determined. Between the velocity v and the explosive work from the unit of mass a there is the relation:

$$m\alpha = \frac{mv^2}{2} \text{ or } v = \sqrt{2\alpha}.$$

If it is desired to express the work of the unit of mass in calories, we have

$$\frac{(v^m)^2}{2 \times 425 \times g^m},$$

which value, of course, indicates gram calories, if the gram is selected as the unit of mass.

the relation between sound and projectile velocities. In the course of experiments carried on in this Institute a few years since, a cylindrical rod of soft wood, about 12 mm. in diameter and 6 cm. long, was inadvertently left in a loaded pistol, and so fired at a ballistic pendulum composed of a soft wood box filled with clay. The rod penetrated the 2 cm. thick side of the box* without breaking or splintering, and remained fixed in the same as though fitted in by a mechanic. In this case the rod penetrated the side of the box and lost its velocity before the time necessary to its sagging or bending had elapsed, which is a fourth of the time of the duration of its transverse oscillation. That, however, the forward end of the rod showed no appearance of being crushed is due to the high velocity of propagation of the longitudinal undulation, about 1000 m. sec. The diminution of velocity of the first cross section of the rod distributes itself so rapidly throughout its whole length that the velocity of all parts of it is reduced at the same rate, so that the great relative accelerations of velocity which are necessary to crush the rod cannot manifest themselves.

Only those cases are here considered which are in consonance with our experience and mechanical instinct, that is, when the velocity of movement and strain is small as compared with the velocity of sound. If the reverse is the case, there result astonishing phenomena which are not pertinent to the investigation. The same, however, lead to a new class of mechanical problems which also require analytical study.†

It is alleged that with very rapidly rotating paper discs very hard bodies may be severed, and Reese‡ of Pittsburg is reported to have cut steel bars with rotating discs of soft iron moving with a rim velocity of 7620 m. per minute. If this is true—we have not so far been able to make sufficiently extensive experiments to prove it—then it is well here also to think of the effect of the projectile velocity, 127 m. sec., of the rim of the disc, and of the circumstance that the same point of the object cut is constantly brought into contact with fresh points of the cutting object.

Daubré§ studied the changes which are wrought upon the surface of meteors by the hot air which they compress in their flight, and Melsens‖ studied closely the effects produced by masses of air which projectiles moving at high velocities carry with them. At the beginning of our experiments we cherished the hope that we would succeed in making visible the masses of air carried along by moving projectiles by means of the Schlieren method, and to reproduce them by photography. To be sure we did not succeed in this, but we are, after the experiments which we will cite, convinced that our non-success was due simply to the smallness of the projectiles and the low velocity which we were constrained to give them. Making visible these air masses appears to us to be of interest for purposes of ballistics and physics, and it is our intention to take the matter up again later on.

In preparing for the solution of the assigned and somewhat difficult problem we solved two less difficult ones. With the aid of commercial dry plates for portrait photography we photographed pistol balls in flight and light undulations. The former is readily done. The ball passes *I*, Fig. 10, between wires

* Some years since I communicated this fact to Mr. J. Papper, an engineer of Vienna, asking him if it were not feasible to make technical use of it. He answered that the American engineer Shaw had hit upon it and made use of it to drive piles in New York harbor, instead of ramming them in as heretofore, attaining great success and precision.

† If we suppose a rod to be stretched and finally rent, then if we regard as abscissae the dislocations of the affected cross section caused by the rending and straining forces, and as ordinates the forces themselves (Fig. 9), then the quadrature of the concerned curves represents the work; and indeed *ab*, *a*, *b*, representing the work of stretching, and *bc*, *b*, *c*, the real work of rending. If the rending is done so rapidly that the stretching can propagate itself only upon a small part of the rod, then the total work will thereby be reduced. It is then reasonable to suppose that the application of very high velocity of strain may yield tangible technical advantages.

‡ Reese, Dingler's Polytechn. Journ. **223**, 545; 1877.

§ Daubré, l. c.

‖ Melsens, Ann. de Chim. et de Phys. (5) **25**, 389; 1882. Compare also The Measuring Machine of Whitworth, German edition, Jena, Costenoble, 1879, p. 7.

Fig. 1.

Fig. 2.

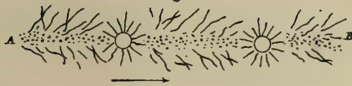


Fig. 3.

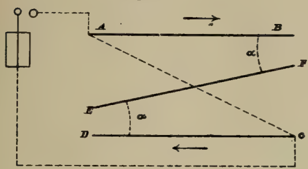


Fig. 4.

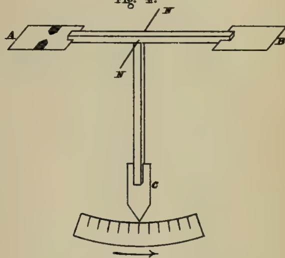


Fig. 5.

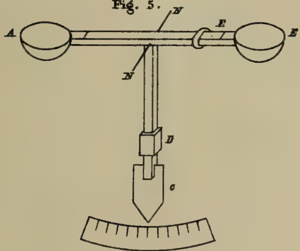


Fig. 6.

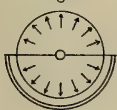


Fig. 7.

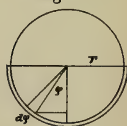


Fig. 8.

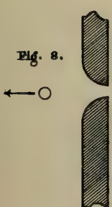


Fig. 9.

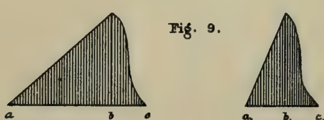


Fig. 10.

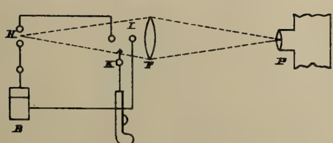
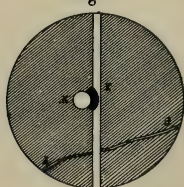


Fig. 11.



which are covered with glass tubing, breaking the latter and releasing a spark from a battery *B* which simultaneously passes across at *H*. The light of the spark at *H*, which in the darkened room illuminated the ball momentarily, making instantaneous shutting off superfluous, is assembled by the lens *F* upon the opening of a photographic apparatus of short focal distance properly placed with reference to *I*, producing a clear and perfect image of the ball, the electrodes at *I*, and of the released spark. From the image it was seen that the spark was only released upon contact of the ball with the electrodes, which latter appeared in the image unchanged.*

The solution of the second problem required somewhat more circumspection. The light undulation which proceeds from a spark *I* is, after it has developed to a certain size, illuminated by a later appearing spark *II*, and made visible by the Töpler Schlieren method,† then photographed. To accomplish this there is necessary a very exact and absolute regulation of the instantaneous illumination, which we will describe more particularly. Otherwise the arrangement of the apparatus is very similar to that in the preceding experiment, only that at *I* there are spherical electrodes whose centres are in the axis of the lens *F*, and which cover the spark. The light of the spark *II*, produced by another battery, is gathered by *F* into an image upon the opening of the photographic apparatus, and is so exactly shaded that only the light turned by the grating, along with that passing the shading, reaches the sensitive plate. With this small quantity of light it is, naturally, only possible to obtain a very small image which can only be observed with a magnifying glass. The beam of light in the negative appears as a dark ring surrounding the electrodes with extremely fine shadings. The image is very transparent, so that it is not suitable for copying, though it marks all the peculiarities which can be observed by looking directly through the apparatus.

PHOTOGRAPHIC DETERMINATION OF THE DISTURBANCES CAUSED BY PROJECTILES IN AIR.

By Dr. P. SALCHER, Professor at the Imperial Austrian Naval Academy.

[Translated by Lieutenant E. H. C. LEUTZE, U. S. Navy, from Mittheilungen aus dem Gebiete des Seewesens, Pola.]

It was stated some time since that a preliminary report, treating of the photographic determination of the disturbances in the air caused by projectiles, had been sent to the Imperial Academy of Sciences at Vienna. Since then another report upon the same subject, by E. Mach and P. Salcher, has been made to the Academy. As it describes the principal features of the experiments in rather an inconvenient form, the object of this paper will be to present the results of the investigation in such detail that the reader will be saved the trouble of looking up the numerous authorities cited.

It should be mentioned in the beginning that the objects of the experiments and the methods used are due to Mr. Mach. The actual experiments, with the exception of a few that were made in elucidation, were made by myself with the able assistance of Professor A. Riegler of Fiume. The report to the Academy is the work of the gentlemen whose names appear above.

Mr. E. Mach, in connection with Mr. J. Wentzel, had already made some

* In regard to this and the succeeding experiments, reports were published not long since in the Anzeiger d. Academie, 1884, No. 15. The accurate aiming necessary in the first experiment was attained by sighting through the barrel of the firmly fixed breech-loader with the aid of a plane mirror.

† Töpler, Observations according to a New Optical Method, Bonn, 1864.

similar experiments, and had reported them to the Academy under the title, "A Contribution to the Mechanics of Explosions."* These experiments were, however, not satisfactory, as will be seen from the following extract of the report, viz. "At the beginning of our experiments we hoped to make the air moving with the projectile visible by the Schlierenmethode,† and thus to photograph it. We were not successful in this; but from the experiments which we will describe farther on, we are convinced that this was due to the smallness of the projectile and the low velocities which had to be used indoors. It seems to us that it would be interesting for ballistic and physical purposes to make these masses of air visible, and we will therefore institute further experiments."

The principle of the method of which Mach and Wentzel made use in order to make the air carried along with the projectile visible, is found first in the works of Foucault, and is later more fully described by Toepler under the title, "Observations according to a New Optical Method." It is learned from the scientific writings of Foucault that not later than 1858 he made use of the following method to test the correctness of the form of spherical concave mirrors.

A spherical concave mirror of perfect shape produces on a screen the image of a luminous point, placed somewhere between its principal focus and the centre of curvature, as a sharply defined disk through which all the reflected rays of the mirror will pass.

If the mirror is faulty this disk is not sharply defined, as the rays of light from the faulty parts will envelop it. If a straight-edged opaque screen is now gradually pushed from the side into the position of the disk, the observer who is looking towards the mirror in the direction given by the luminous point and its picture, will see the light of the mirror gradually decrease, and at the moment the screen is pushed entirely across the light will be extinguished; the transition from light to darkness is clearly and sharply defined. This phenomenon is different with an imperfectly spherical mirror. When the screen is gradually advanced, the light from the mirror is not as in the last case gradually and progressively lessened, but light and dark spots more or less regularly distributed will be seen on the surface of the screen. This method of Foucault's is remarkable for its great sensitiveness in discovering any irregularities in the curvature of concave mirrors.

The principle of Toepler's method is similar to the above. He used it in finding (schlieren) imperfections in condensing lenses. And he perfected this method (Schlierenmethode) so that it could also be applied to find irregularities, not only in fluids, but also in gases and in air. This remarkable result was attained as follows:

II in the figure represents a luminous point whose rays partially pass through the converging lens *OO*, which is a little more than its focal length from *II*. After passing through the lens the rays converge, and, after producing an image, diverge again. This is the course of the rays under normal conditions. Should, however, some disturbing cause be put in the path of the rays, either between their starting point and the lens, or on the other side of the same, or still farther on, part of the rays will be thrown out of their regular path, pass the image, and will make this disturbance manifest. We have, therefore, regular and irregular rays which can be separated from each other by advancing an opaque screen so far into the position of the image

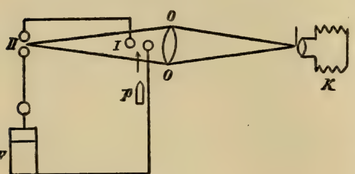


FIG. 1.

* See translation of this article, page 258.

† Schlieren = flaws or streaks in glass.

(marked K in the figure) that the regular rays are entirely shut out, whereas the irregular rays will pass by the edge of the screen. These irregular rays can then be seen by the observer either by the aid of a telescope or without it, and he is thus notified of the disturbance.

We will now quote a few experiments made by Toepler illustrating the sensitiveness of the Schlieren method. The least heating of the air in the path of the rays of light will render the air visible, as the warm air rises in the shape of a flame into the colder masses. Alcohol dropped on water causes a violent disturbance in the air, during which hoop-shaped bands are seen to intermingle irregularly. If a glass trough filled with water is put into the path of the rays of light, and a slight movement of the air is produced at the surface of the water, the cooling of the air due to evaporation is made by this method very apparent. The water cooled in consequence of evaporation will be seen to seek the bottom until regular whirls are produced, which sink near the walls of the trough and rise in the centre. Waves of sound produced by an electric discharge also become visible; if these are reflected it will be discovered as well.

Toepler's method was only deficient in one particular, and that was, the phenomena observed could not be graphically represented. Mach overcame this by substituting the photographic camera for the telescope. As soon as this was accomplished this method became available for the study of new experiments, one of which was the disturbance in air caused by projectiles.

The essential parts of the Toepler-Mach method as used to determine this disturbance in air, are as follows: The circuit of a Leyden-jar battery (Fig. 1) contains two breaks, I and II. At I the electrodes consist of metal wires encased in glass tubes to prevent the passage of the spark. The projectile breaks these tubes and the battery is discharged, causing sparks at I and II. The partially screened spark II illuminates the projectile in front of the lens O. This lens produces the image of the spark II by means of the regular rays in front of the lens of the camera, and this image is either entirely or partially screened. Of the disturbed rays, at least a part passes by the screen and produces on the dry plate the image of the projectile with the electrodes, sparks I and the changes of condensation in the air. All this occurs during the momentary illumination which is produced in the darkened experimental room by the projectile itself.

Lens O was an objective by Voigtländer, and the photographic lens was made by Steinheil.

The distance IIO was 48 cm., OK 230 cm. The muzzle of the rifle was differently placed at distances from 4 to 6 metres from the electrodes I. The illuminating powder also varied. A single Leyden jar having a capacity of 410 cm. and a striking distance of from 6 to 7 mm. was finally used for this purpose. Too large capacity of the jar gave too great a duration to the spark, which blurred the pictures, and sometimes, owing to the residual discharges, produced more than one image.

The trials were made with—

1. Werndl infantry rifle, initial velocity 438 m./sec. ($\pm$ 5 m./sec.), calibre 11 mm., length of projectile 27 mm.
2. Werndl carbine, initial velocity 327 to 339 m./sec.
3. Guedes infantry rifle, initial velocity calculated from an empirical formula of Hebler 522 m./sec., according to the ballistic pendulum 530 m./sec., but officially announced as 505 m./sec., calibre 8, length of projectile 33 mm.

For photographic purposes the dry plates of commerce were used. The pictures had to be very small to make the given light sufficient for their production; the photographs, as reproduced in the plate, being much enlarged. When the straight-edged screen was placed vertically, the limits of the condensation of the air were either light or dark; but when the screen was placed vertically this limit showed partially light and partially dark.

The projectile shows light on half dark background, and its limits are sharply defined by the refraction of the light. About 80 good negatives were taken which contain much interesting detail. Sound waves originated by the

discharge at *I* are visible on nearly all the negatives. The paths of the pieces of the broken glass tubes are also visible. There was much else besides.

NOTE.—When a telescope was put at the electrodes *I*, all the phenomena represented on the negative could be plainly seen. The projectile seemed to be stationary, surrounded by a magnificently colored halo not unlike the appearance of a comet.

The principal results of the experiments may be briefly summarized as follows :

1. A condensation which can be optically proven, or rather its limits, can be seen in front of the projectile when it has a velocity greater than that of sound (about 340 metres). The experiments with the carbine were therefore fruitless, as well as the first ones made with a parlor rifle by Messrs. Mach and Wentzel. The limits of condensation can be clearly seen when the Werndl or Guedes rifle was used and all the adjustments properly made.

2. The limit of condensation is similar to a circumscribing nappe of an hyperboloid whose conjugate axis lies in front of the projectile and whose transverse axis lies in its path. If this hyperbola is revolved around its transverse axis we have the limit of the condensation in space. Other straight lines of condensation are seen to diverge symmetrically from the edges of the base of the shot towards the rear. Similar but less plainly defined straight lines emanate from other parts of the shot. The angles these lines make with the trajectory become smaller as the velocity increases.

3. With the greatest attained velocities a new phenomenon was observed, namely, the "wake" of the shot became filled with small clouds. These will be treated of farther on.

In order to explain the principal phenomena let us assume that an infinitely thin staff *ab* (Fig. 2) of finite length be moved in the direction *ba* with a velocity greater than that of sound. This causes at the point of the staff continual but infinitely small condensations, which spread out and enlarge in the manner of concentric spherical calottes, about their point of origin as centres, in proportion as the staff moves forward. The envelopes of these elementary waves produce a cone, and at the same time, according to Huyghens' laws, a wave itself, whose section on the plane of the drawing is represented by *man*. If we call the angle $mab = a$, the velocity of sound $= v$, and that of the staff $= \omega$, we have

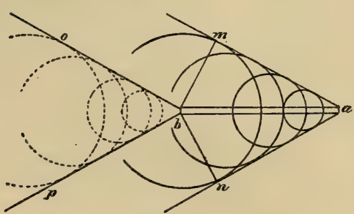


FIG. 2.

$$\frac{v}{\omega} = \frac{bm}{ba} = \sin a.$$

Now, in proportion as the condensation takes place at the forward end of the staff, rarefaction will take place at the rear end *b*, and this will also produce a wave having the same equation.

If $\omega = v$, then $\sin a = 1$; that is, in case the velocity of the staff (or projectile) equals that of sound, then will the forward end, *a*, of the staff touch all the elementary waves which it has produced (Fig. 3). The same holds true for the rear end of the staff. If, however, the velocity of the staff becomes less than that of sound, the equation loses all geometrical meaning. The staff is then overtaken and beaten by the elementary waves, which will neutralize each other instead of collecting. This is similar to Huyghens' experiments with the interrupted ray of light in case of total reflection.

If it is, for example, assumed that the staff, moving forward with half the velocity of sound, has arrived at a (Fig. 4), then the elementary waves which were produced at the points m, n, o, p, and which have assumed radii of twice ma, twice na, twice oa, twice pa, will here gain a long distance in advance. The waves are lettered in the figure with the same letters as the origin.

From these simple observations we draw the following conclusions:

1. The appearance of a sharply defined limit of condensation is dependent upon the condition $\omega \geqq v$.

2. For the condition $\omega > v$ the relation of the velocity of the sound to that of the projectile can be seen from sin a.

This explains the first, and partially the second, phenomenon.

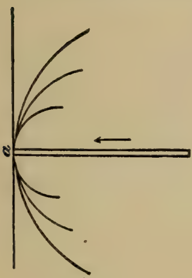


FIG. 3.

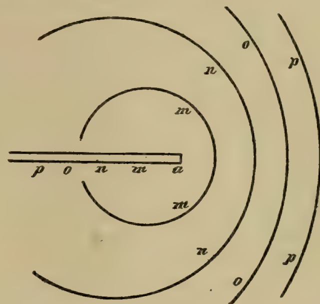


FIG. 4.

To return to the experiments, let us assume that a body of finite section is moving through the air. It will produce finite, and with great velocity even considerable, condensation. It has been proved by the experiments of Lagrange, Poisson, Stokes, Earnshaw, Riemann, and Tumlirz, and also those of Regnault and Mach, that these condensations will advance with a velocity that is greater than the normal velocity of sound. The velocity with which the condensation of the air in front of the body spreads, can, with corresponding increased velocity of the body, become infinitely great. It could even be said that the condensation before the moving body can become infinite, or that the air itself will be destroyed. With the extension of the wave, however, the condensation and the rapidity of transmission (spreading) diminish.

When the above remarks are applied to the velocity of the projectile, it will be seen that in the case when the shot moves more rapidly than sound, the condensation in front of the shot must increase until its velocity of propagation becomes equal to that of the shot. When this takes place, all cause for further change is removed, and the condensation in front of the shot remains the same in shape and size.

As the greatest condensation takes place immediately in front of the head of the projectile, and the velocities of the two are equal, and as, furthermore, the condensation and velocity of the wave decrease as expansion takes place, it follows that the meridian line of the limiting surface of wave is not a broken line, but a curve which runs backward from the vertex, the angle of its tangents gradually decreasing until it approximates to the limit arc $\sin\left(\frac{v}{\omega}\right)$. This is evident from former remarks and also from the figures. The meridian curve is therefore similar to the branch of an hyperbola, but the exact curve cannot be obtained with the present data.

If we suppose that the projectile remains in steady motion, and the wave of sound in front of it is stationary, then when the velocity of the projectile decreases, the crest of the wave will move farther from the shot until the condensation has so decreased that the velocities of the sound and projectile are reduced in the same proportion. If the velocity of the shot is increased, the contrary will take place. Other things being equal, the crest of the wave will therefore be nearer to the projectile when the velocities are larger. This is shown by the pictures.

If the shot be pointed, it is evident that the crest will also close in, and the condensation (under other similar circumstances) will become smaller. Should it be desired that the condensation be as large as with round-headed projectiles and equal velocity, then the point must be brought closer to the crest of the wave.

The influence of the shape of the head of the shot on the distance of the crest of the sound wave from it can also be explained as follows: Assume again that the motion of the shot is steady, and that the sound wave in front of it is stationary. If now the head of the shot be pointed, without otherwise changing its form, the disturbance in the air will be less, and will therefore become accelerated, bringing the wave sound closer to the point of the projectile. (See photographs.)

We have shown heretofore that the limit of the sound wave can be found by Huyghens' laws, and also that this wave is similar in shape to an hyperboloid. The wave limits which emanate from the edges of the base of the shot deviate least from the true curve shape, for they are at the place of junction of rarefaction and condensation of the air and where the velocity of sound is about normal.

The equation $\sin \alpha = \frac{v}{\omega}$ is nearly true for these waves, and is least applicable to the "meridian curve" of the front wave, as it is only satisfied by the asymptotes of the hyperbola.

An attempt was made to measure the angle χ by means of Leson's double refraction goniometer, but the small size of the negatives made it very difficult. The advantage gained by enlarging the photograph three times was slight, and was counterbalanced by the other details which were brought out in the pictures. The velocity of shot was in m./sec. as follows:

	Officially announced.	According to ballistic experiments.	Calculated from the forward waves.	Calculated from the back waves.
Werndl rifle,	438	445	375	460
Guedes rifle,	505	530	465	570

The ballistic pendulum observations (given in column 3) were very limited in number, as the pendulum was destroyed. It will be seen that the angle α of the limit of the forward wave gave a velocity too low for the projectile, and that of the limit of the back wave one too high. If the officially stated velocity be taken as the correct one, it becomes possible to calculate the increase in the velocity of sound from the forward limit. This velocity near the edge of the negative is still about 400 m./sec. The decrease in α as ω increases undoubtedly takes place.

The stripes which are seen between the lines representing the limits of the forward and after waves have not been as yet fully explained, but it seems very likely that they are due to unequal friction and the whistling of the shot.

The examination alone of the pictures teaches that the condensation of the air in front of the projectile must be considerable. The waves certainly belong to the same category as those produced by electric discharges, which Mach found to have a velocity of propagation equal to 700 m./sec., and whose minimum condensation amounted to 0.15 of an atmosphere.

With a high velocity of the projectile the strange appearance of small clouds

in the wake of the shot is very noticeable in the photographs. They appear like pearls strung regularly and systematically on a string stretched in the path of the projectile, and bear a strong resemblance to the clouds of heated air which the electric spark causes in the atmosphere it traverses, and in which, by means of the Schlieren method, whirls can be plainly detected.

It is very likely that such whirls exist in rear of the projectile, as the masses of air which are adjacent to the base of the shot will by reason of friction rush into the rarefied air with less velocity than the air which is farther off. We have therefore all the conditions necessary to produce whirls, and these are even more favorable when the velocities are high enough and the diameter of the base of the shot sufficient to produce a vacuum, which will produce an intermittent influx of air. Now, although it is easy to understand that the whirls are produced in the wake of the shot, it is harder to explain why these whirls become visible by the Schlieren method. According to that method, only differences in the refractive power can be discovered, but not simply the movement of air. If these clouds were air condensed or rarefied by changes in pressure, they would cause sound waves, and consequently the already familiar phenomena; but this supposition is not tenable, as these clouds are still seen for a long distance in the cylindrical wake of the projectile.

These clouds or whirls can, therefore, only consist of a different gas from air, or of air with a higher temperature. It will immediately occur to us that they are caused by the gases of the explosion; and this seems more plausible when the vacuum in rear of the shot is taken into consideration. On the other hand, the following facts are against this explanation, namely, the distance (4 metres of the muzzle of the gun from the negative), and that the whirls are smaller the farther they are from the projectile; the contrary would be the case if their origin is the explosion. The simplest explanation seems to be that the air rushes in whirls into the vacuum, the friction and collision thereof causing heat and rendering it visible. It will be necessary to make further experiments which are not entirely based on optical observation in order to settle this point.

The study of the photographs will undoubtedly recall an already familiar phenomenon. The projectile causes the same disturbance in the air that a ship makes in moving through the water, Fig. 5. The forward and after wave limits, as well as the back water in the wake, can be plainly seen and the phenomenon can be easily produced by dipping a staff of the section *ab* in a tub of water and moving it forward. As soon as the speed of the staff exceeds that of the waves the wave crests will appear. If the staff is moved slowly and the water strewn with gold-bronze dust, the whirls can be readily seen. As the phenomenon merely depends on the relative movement between water and a solid body, it can be observed at any bridge pier against which the water rushes; it is even clearer in this case, as the disturbance caused by the motive power of the vessel disappears. It is self-evident that in order to produce the crest in the case of the pier, the velocity of the current must as much exceed that of the wave as the speed of the ship exceeds that of its wave in producing the same result.

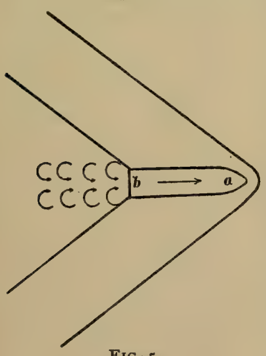


FIG. 5.

The observation that the phenomena occurring around the projectile only depend upon its relative motion to that of the air, permits the assumption of

another point of view for the observation of the motion of the air. It is possible to regard each beam of sound waves as stationary, if you assume that the medium will flow against the direction of the propagation of and with the velocity of the sound. This wave would then appear to an observer who is at rest somewhat as the tide wave, with the earth turning underneath it, would look to an observer on the moon. Or it could be assumed that the wave caused by the projectile is stationary if the projectile is in a quiescent state while the air is moving towards it with a velocity equal to that of the projectile. The question now arises: Can this motion of the air be determined from the photographs through the stream lines which appear in them? It may be remarked here that the knowledge of the density alone at each point suffices to indicate the further progress of a sound wave, and the velocity of the particles of air must also be known. If air becomes condensed in a tube, this, as was already known to Euler, is not enough to determine whether the sound wave will dilate in one direction or the other, or whether it will split in two. But if the wave is disturbed by some solid body, or if the wave be assumed to be stationary, then are the velocities as well as densities determined. The solution of the above question would therefore demand the knowledge of the densities in the neighborhood of the projectile. The analytical treatment would, however, still be difficult, on account of currents in space, the influence of friction, the shape of the projectile, etc. Problems of currents, assuming them to be stationary, are generally more easy to solve.

In order to prepare for the analytical discussion we must, on account of the insufficiency of the results of the experiments, develop a qualitative picture of the phenomena which take place in the air around the projectile. To this end we can profit by the experience gained by Mach and Weltrubsky when experimenting with spark waves. It was shown that the densities change in the direction parallel to the axis of the shot, as shown in the curve, Fig. 6. The ordinates of this curve from the straight line which represents points of the wave (v a point belonging to the forward wave limit and h one of the after wave limit) give the density of the air. Besides, it can also be assumed that the densities diminish as the distance of the axis of the projectile from an assumed parallel straight line increases; the ordinates becoming smaller and approximating closer to those of a sine curve as this parallel line is assumed farther from the axis of the projectile.

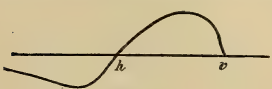


FIG. 6.

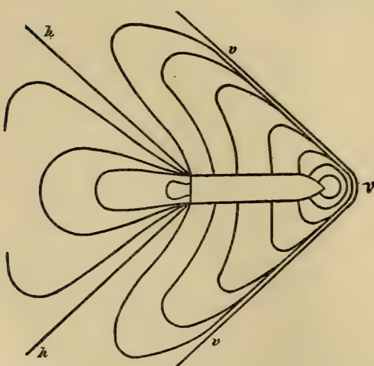


FIG. 7.

If the points of equal densities (or pressures) are connected, we have the curves of equal densities shown in Fig. 7. As the stream lines cut these curves perpendicularly, they can be easily drawn in. They run diverging from the point of the shot partially to the front and partially backwards towards the base of the shot, and are joined there

Photo. 1.

Photo. 2.

from the rear by farther distant stream lines. The quiescent air will in fact partially give way to the front, partially flow to the rear, and partially follow back from the rear toward the projectile. Supposing, however, that the air rushes with the velocity of the projectile against the stationary projectile, then the above named velocities will have to be applied to the progressive velocity of the air current according to the principle of geometrical progression. From this we deduce that the particles at the point of the projectile diminish their velocity; the former parallel courses will avoid the projectile and will again close in behind them.

The above representation and its discussion, and the principal phenomena shown on the photographs, are still far from perfect. They assist, however, in the solution of the problem by showing the disturbances in the air around the projectile, and call attention to those points which require further elucidation by experiments. Foremost among these is the quantitative determination of the pressures that the air is exposed to at different points in the vicinity of the projectile. It is possible that we may have some data at hand which could be used similarly to those employed by Mach and Weltrubsky to find the differences in densities in the waves produced by the discharge of an electric spark. Further experiments are also required to determine the influence of friction, of the rotation of the shot, and also of the discontinuity of the air behind the projectile. The continuation of the experiments will probably also be of great interest to artillerists. By the experiments already made it becomes clear that part of the energy of the shot is used in sustaining an enormous sound wave and in creating whirls. Furthermore, they enable us to explain the empirical laws of resistance theoretically, and also show us that Froude's experiments in water with small models can be used for the purpose of improving the shape of the larger projectiles.

Explanation of the Photographs.*

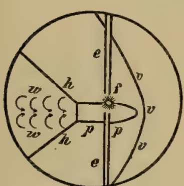


Fig. 8.

The photographs are further explained by Fig. 8, namely, *pp* the projectile, *ee* the wire electrode, *f* the electric spark *I*, *vv* the front and *hh* the rear wave limits, and *ww* the whirls.

Photograph 1 shows the experiment with the Werndl infantry rifle, and photograph 2, that with the Guedes rifle. The projectile travels in all the pictures from left to right. Photograph 1 shows the front wave, and photograph 2 the rear wave and the whirls. A circular spark-wave is seen around the spark on most of the pictures. The pictures are, as before stated, enlarged, and are reproduced as faithfully as possible by the lithographic process.

STEERING APPARATUS.

Patented by Lieut. R. M. G. Brown, U. S. N., March 11, 1884.

The essential feature of this invention is the combination of the ordinary steering gear with the throttle of a steam pump and the sluice or gate of its discharge pipe, in such a manner that when steering with *small helm* neither of these is opened and the hydraulic power is not brought into play, but when the helm is put *hard over*, or nearly so, the hydraulic sluice (a two-way cock)

* Eight photographs were used to illustrate the original article, but only two of the best are here reproduced.

is opened so as to throw the stream of water in the proper direction to reinforce the rudder, and at the same time the throttle of the steam pump is opened.

As described in the specifications of the Letters Patent (No. 295,106), a crank-arm, *e*, secured to the rudder spindle, is connected by a rod *h* to a crank-handle *f* operating the two-way cock in the hydraulic pipe, which is branched at the seat of the cock, one branch leading to the starboard side and the other to the port side of the vessel. This crank-handle *f* is connected by another rod *i* to a crank-handle *g* operating the throttle valve of the steam pipe.

When the tiller is put to starboard, for instance, the end of the crank-arm *e* moves aft, and with it the connecting rods *h* and *i* and the crank-handles *f* and *g*. The throttle valve, however, is so constructed that no steam enters the pump engine until the tiller is put hard over, or nearly so, and therefore, as there is no flow of water, it is indifferent whether or not the sluice gate is opened. But when the tiller is put well over, the throttle opens, the flow of water commences, and the sluice having been so turned (in this supposed case) that the discharge is through the opening in the port side, the hydraulic force so created reinforces the effort of the rudder to turn the vessel's head to port. If the tiller is put to port a similar action takes place, but in the opposite direction.

The inventor distinctly states that he does not claim as novel either of the elements of the steering apparatus separately, but he does claim the combination of them all when arranged to co-operate in the manner briefly described above. S. W. V.

Jan. 17, 1888.

THE STEAM TRIAL OF THE U. S. STEAMER CHICAGO.

[Reprinted from *The Engineer*, New York, N. Y.]

The wide-spread interest felt in the performance of the Chicago, and the results of her recent successful trial in Long Island Sound, induces us to publish fuller details of the trip, a slight allusion to which was made in the last number of our paper. The official reports are now before us, and we present a synopsis of their contents.

First in order is that of her commanding officer, who states the weather was clear, with a moderate sea, but a strong gale blowing from the northward and eastward. The force of the wind is not counted either for or against the vessel, but on her return trip it blew much harder ahead than it favored her in starting out.

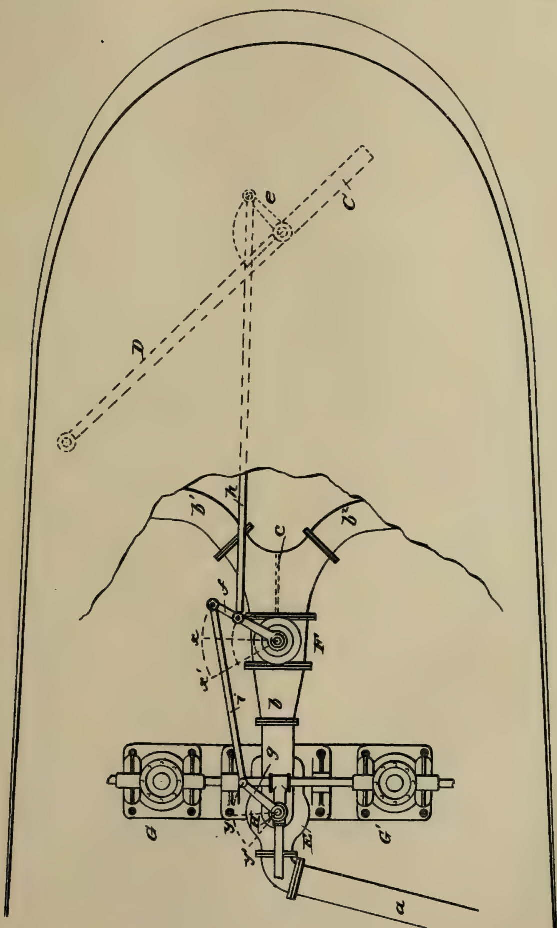
The distance steamed was most carefully measured by both patent and chip logs and by observed bearings, and was computed in the report of the navigating officer as 90.63 sea miles. The only allowed tide was 5.43 knots, which is conceded to be the minimum, as it was strongly adverse both going and returning.

The average speed for the six hours was 15.13 knots per hour, and the maximum for one hour 16.35 knots. The ship steered easily, and the steam gear, furnished by the Messrs. Williamson, of Philadelphia, worked most efficiently. The loosening of an eccentric bolt caused a temporary change to the hand gear, but only a few moments were necessary to make everything permanently secure. The builders of this steering gear were both chief engineers in the U. S. Navy during the war, and they have here proven that they know what is required for a steam steerer for a large vessel of war, and also how to make it.

With the capstan some difficulty was experienced, not with the machine itself so much as with the lead of the chain; but the makers of this machine,

STEERING APPARATUS,

Patented by Lieut. R. M. G. BROWN, U. S. N.



the American Ship Windlass Company of Providence, have the remedy for that difficulty already under way.

Before the trial the vessel was filled with coal and iron ballast put on board to compensate for the absence of guns, etc., so that the Chicago was at her full sea displacement of 4556 tons. The draught of water was, forward, 17′ 4″; aft, 20′ 8″; mean, 19′ 0″.

For nearly six months previous to this trial the vessel had been lying at the docks of the Navy Yard, in the Wallabout, so that her bottom was somewhat fouled by that cesspool for Brooklyn sewers, and the ship was not in a condition to give the best results for speed at the horse-power obtained.

Captain Robeson speaks in the highest terms of the vessel and of the ease with which she can be handled; from the Navy Yard to Blackwell's Island she was steered in a strong tide-way by means of the twin screws only, on account of some derangement in the clutch coupling of the steam steerer.

The design of the vessel in 1882 contemplated a mean speed of 15 knots per six hours, a measured mile speed of 16 knots, and an indicated horse-power of 5000, all of which have been more than realized. The report of Chief Engineer Thomson is accompanied by a table of the indicated horse-power, steam logs, etc.

U. S. S. CHICAGO, FIRST RATE.—*Long Island Sound, December* 16, 1887.

FORWARD ENGINE. SYNOPSIS OF INDICATOR CARDS.

No. of Card.	Time.	Steam at Engines.	Initial pressure above atmosphere. H.P.	Initial pressure above atmosphere. L.P.	Revolutions per minute.	Vacuum.	Mean Pressures. H.P.	Mean Pressures. L.P.	Indicated Horse Power. H. P.	Indicated Horse Power. L. P.	Total I. H. P.	Aux. I. H. P.	Collective I. H. P.	Remarks.
1	10	88.	85.	22.5	69.5	24.5	34.35	14.26	1084.56	1360.45	2445.01	359.84	5054.468	The cost of the I. H. power, inclusive of the large amount of steam used by auxiliary machinery, approximates to 2.25 pounds of coal.
2	10.30	87.	86.5	27.	71.	25.	35.58	15.80	1147.63	1539.90	2687.53	2 Air and Circulating Pumps.	5248 419	
3	11	86.	83.5	25.5	70.5	25.	34.07	15.15	1091.35	1466.14	2557 49	2 Air and Circulating Pumps (aux.).	5076.331	
4	11.30	86.	79.5	23.5	68.	25.	32.38	14.79	1000.13	1380.55	2380.68	2 Steam Feed Pumps.	4864 862	
5	12 M.	82.	79.	25.5	69.	25.	31.80	15.60	996.84	1477.57	2474.41		4998 966	
6	12.30	87.	83.	24.	70.	24.5	34.15	15.02	1086.00	1443.26	2529.26		5086.326	
7	1	87.	84.	24.	70.	25.5	34.85	15.26	1108.26	1466.32	2574.58		5158.028	
8	1.30	85.	82.5	23.5	70.	25.	33.98	14.66	1080.60	1408.67	2489.26		5100.515	
9	2	85.	85.	24.	68.	24.5	34.28	15.05	1058 98	1404 83	2463.87		5044.166	
10	2.30	85.	82 5	22.5	68.	25.	34.80	15.83	1075 04	1477.64	2552.68		5116.204	
11	3	84.	79.	25.5	68.5	24.	33.18	15.73	1032.53	1479 09	2511.62		5104.041	
12	3.30	86.	84.5	25.	69.	26.	34.00	15.22	1065.80	1447.58	2507.37		5153.131	
Mean.		85.7	82.8	24.4	69.3	25.0	33.78	15.28	1068.98	1445.49	2514.47		5083.780	

AFTER ENGINE. SYNOPSIS OF INDICATOR CARDS.

No. of Card.	Time.	Steam at Engines.	Initial pressure H.P.	Initial pressure L.P.	Revolutions per minute.	Vacuum.	Mean Pressures H.P.	Mean Pressures L.P.	Indicated Horse Power H. P.	Indicated Horse Power L. P.	Total I. H. P.	Aux.
	A. M.											
1	10.15	86.	83.	24.	70.5	25.5	32.80	12.40	1049.60	1200.01	2249.61	1 Water Service Pump.
2	10.46	86.	80.5	22.5	70.5	25.5	32.25	12.08	1032.00	1169.04	2201.04	2 Drainage Pumps.
3	11.15	82.	76 5	23.5	70.	25.	30.45	12.40	967.49	1191.50	2158.99	1 Flushing Pump.
4	11.46	80.	78.	23.	69.5	25.	31.05	12.00	979.50	1144.84	2124.34	1 Pair Steering Engines.
	P. M.											8 Fire-room Blowers.
5	12 16	84.	82.	24.	70.	25.	31 75	12.03	1008.79	1155.95	2164.74	2 Ventilating Blowers.
6	12.47	85.	84.5	24.5	70.	25.	32.50	12.12	1032.62	1164.60	2197.22	1 Compartment Pump.
7	1 16	85.	83.5	23.5	70.	25.5	33.30	12.13	1058.04	1165.56	2223 60	
8	1 47	83.	79.	24.	68.	25.	34.48	12.72	1064.07	1187.44	2251.41	
9	2.16	83.	79.	23.	67.5	25.	34 55	12 54	1058.54	1161.92	2220.46	
10	2.47	83.	79.	23.5	68.	25.	33.08	12.67	1021.01	1182.67	2203.68	
11	3.15	84.	83.	24.	68 5	25.5	33.70	12.60	1047.80	1184.77	2232.57	
12	3.26	87.	83.	24.5	69.5	25.	33.45	12.90	1055.21	1230.70	2285.91	
Mean.		84.	80.9	23.7	69.3	25.2	32.78	12.38	1031.22	1178 24	2209.46	

The engines worked admirably throughout the trial; it was never necessary to stop or slow them, and by means of the steam reverse gear they were handled with the greatest ease. There were no hot journals, the only ones causing any trouble being those near the after crank pit. The drainage of this

pit was insufficient and, in fact, washed the oil from the adjacent bearings. The engines worked smoothly, without jar or pounding; in fact, when at a piston speed of nearly seven hundred feet per minute it was necessary to open the bulkhead doors when on deck above to ascertain if they were in motion. The throttle was wide open throughout the trial.

The auxiliaries all worked continuously and satisfactorily, with the exception of one pair of blowing engines that were temporarily deranged. The air and circulating pumps, on the Blake system, were remarkably efficient and fully carried out the guarantee of their design, viz., to perform the work required at less than two percentum of the I. H. P. The average strokes of the pump were 44 per minute, equal to a pump piston speed of 88 feet. They were built by the George F. Blake Manufacturing Company of New York and Boston.

The average speed of the blowers was 500 revolutions per minute, and the immense volume of air carried down to the fire rooms not only gave all the air required for the furnaces, but maintained a temperature not averaging above 95 degrees. The ventilation of the hull, living spaces, etc., was obtained by a system of exhaust ducts leading to two large blowers, made by the Sturtevant Company of Boston, Mass.

The coal was semi-bituminous, of the New River variety, excellent in quality, but the greater part of it too small for efficient fires. It burned freely, leaving but a small percentum of ash and but little clinker.

The boilers were tested before the trial to 150 pounds hydrostatic pressure and were very tight. There was no lack of capacity in them to give an ample supply of steam, but the fire room crew were hastily collected from the receiving ship and other vessels and had no training or experience; in fact they had never been assembled before meeting in front of the furnaces. The only difficulty regarding the steam arose from the safety valves; they were set slightly above the working pressure and would frequently open; this was not objectionable, but they would not close until the pressure had fallen some pounds.

The depth of the furnaces was reduced from the original design to bars of 6′ 0″ length, corresponding to a grate area of 624 square feet; even this was more than sufficient to produce the horse-power required by the contract. The boilers, it is to be remembered, are externally fired, from furnaces constructed of wrought-iron framing lined with fire-brick.

No attempt was made to economize fuel, but the cost per I. H. P. approximates (inclusive of the large amount of steam used by the auxiliaries) to 2.25 pounds per hour.

The mean I. H. P., calculated from the mean of the mean pressures and mean number of revolutions observed from counter, taken at the beginning and end of trial, was 5063.67 I. H. P.

The mean I. H. P., calculated from diagrams and revolutions marked at time of taking the cards, was 5083.78. The maximum observed from both engines at one time was 5284.41.

The average slip of the screw was 10.1 percentum; the ratio of the diameter to mean pitch, 1 : 1.586, is rather above the average of general practice. The mean revolutions per minute for six hours were 69.3; the maximum revolutions per minute observed, 73; the mean speed of piston in feet, per minute, 658.35; the maximum speed of piston in feet, per minute, 693.5. Observation of the foregoing tables brings prominently to notice the high pressure maintained in the receiver, it being 24.75 pounds. The power developed by the two high pressure cylinders was remarkably uniform throughout, and relatively, but there is a marked difference between the low pressure cylinder power of the forward and after engines, accounted for in part by the blowing out of the joint on equalizing valve of the after low pressure engine.

The machinery of the U. S. S. Chicago was in its main features suggested to the Naval Advisory Board by Mr. Miers Coryell, then a member of that board. Many of its details were a matter of compromise with his associate

members. No marine engine was ever subjected to more severe criticism than those fitted to the Chicago, but the performance cited above proves that the principles involved have been subjected to the severest test and have completely refuted the critics and vindicated Mr. Coryell's judgment and engineering ability. Under the most discouraging circumstances this trial has been brought to a remarkably successful termination, and Chief Engineer Alexander Henderson, United States Navy, who had the general command of the detail work, and Chief Engineer Thomson, under whose direction the machinery was erected and tested, are to be congratulated. We are also naturally pleased; for we burned our bridges behind us, and [we now] freely forgive foreign and domestic critics who predicted the Chicago's utter failure and said so many hard things about us.

The condition of the Chicago's hull, the inexperience of her crew, *et al.*, have prevented showing her maximum speed. This trial was made with open fire rooms, assisted with blowers. A thoroughly drilled crew will enable the Chicago to develop 5750 I. H. P.; this trial was simply a contractor's trip to carry out the requirement of 5000 H. P.; beyond that the machinery was not urged. It was necessary to close the fire rooms and resort to forced draught, as the supply of steam was ample for 5000 I. H. P. The tests previously made showed the tightness of the several fire rooms by a maintenance of 1¼ to 1½ inches of water pressure.

For reference, we give from our published description of this vessel, Vol. X, No. 11, of November 28, 1885, the following dimensions, relating to the engines, which are of the overhead working beam type:

Cylinders—forward engines—H. P. 45", L. P. 78"×stroke, 57.163.

Cylinders—after engines—H. P. 45", L. P. 78"×stroke, 57.187.

Constants—forward, high pressure, .4543, L. P. 1.3727.

Constants—after, high pressure, .4539, L. P. 1.3727.

Screws—twin—Hirsch pattern—four blades—diameter 15' 6", mean pitch, star. 24'.437, port 24'.578.

Blades—cast solid—area of each screw, 77,933 sq. ft.

(For complete dimensions of hull, machinery, ratios, etc., see our issue of above date, with engravings of engines and boilers.)

BIBLIOGRAPHIC NOTES.

AMERICAN CHEMICAL JOURNAL.

VOLUME 9, NO. 2, APRIL, 1887.

A. E. Menke has found that alkaline carbonates prevent to a certaint extent the destructive effect of ferric sulphate on boilers. Potassic carbonate he finds best, but recommends, as cheaper, 1½ grains sodic carbonate for every grain of ferric sulphate found in the water.

NO. 4, AUGUST.

E. H. Keiser describes a simple and convenient form of pyrometer. *Notes:* Mention is made of the discovery by Curtius, of diamide or hydrazine, $(NH_2)_2$, a stable gas, of peculiar odor, soluble in water with alkaline reaction.

NO. 6, NOVEMBER.

W. O. Atwater epitomizes some of the principal results of his investigation of the chemical composition and nutritive values of American food fishes (monograph to be published by the U. S. Fish Commission). *Notes:* Mention is made of Christensen's recent determination of the atomic weight of fluorine (18.94 when hydrogen = 1.)

VOLUME 10, NO. 1, JANUARY, 1888.

W. O. Atwater concludes his article on American food fishes, begun in Vol. 9, No. 6. J. H. Long has investigated in behalf of the Illinois State Board of Health, the oxidation and consequent partial purification of the sewage of the city of Chicago during its flow, by canal, into the Illinois river. I. A. Bachman utilizes the waste acids of a spent Grove cell, in place of hydrochloric acid, to form a freezing mixture with snow. C. Catlett and R. C. Price find the composition of a "Hand Fire Grenade" to be such as to suggest the belief that the liquid is obtained by mixing two volumes of water with one volume of waste mother liquors from salt wells.

C. R. S.

ANNALEN DER HYDROGRAPHIE, ETC.

PART IX, 1887. Typhoons in the China Sea. Cruising notes of the German brig Sütkin, by Captain Inhülsen. Observations on Kaiser Wilhelm's Land, Bismarck Archipelago, Apia and Sefuka. Observations of the sea temperature in the eastern part of the South Atlantic Ocean and in Walfish Bay. Researches of Elias Loomis on barometric maxima and minima, discussed by Dr. J. Van Bebber. On testing chronometers. Meteorological and hydrographic notes. Tables and miscellaneous notices.

PART X, 1887. Uniform systems of buoyage with special reference to the German system. Hydrographic notices on Java, by Captain J. Hemdorff. The Adriatic Sea. The clouds in eastern part of the North Atlantic Ocean, by Dr. W. Köppen. Small notices. Storm signals in America and hydrographic notes. Tables.

PART XI, 1887. Uniform systems of buoyage with special reference to the German system (conclusion). Notes on the harbors in the Persian Gulf. Small notices. Meteorological and hydrographic notes. Use of oil in storms at sea.

PART XII, 1887. On the earth's magnetism, by Dr. P. Andries. Influence of lightning on the compasses of the German ship Bismarck. Contributions to the description of east coast of Africa. Notes from the cruise of the German bark Aeolus. Notes on Callao, Corinto, Punta Arenas, Chira, and Icacal. The Aden cyclone of June, 1885. Inquiries as to the influence of the moisture of the air on the running of chronometers. Cruising records of ships of the German Navy for 1887. Miscellaneous notes. Meteorological, hydrographic, and literary notices. J. T. S.

BULLETIN OF THE IRON AND STEEL ASSOCIATION.

VOLUME XXI, NO. 45, DECEMBER 28, 1887. Present number and capacity of the iron and steel works of the United States.

VOLUME XXII, NO. 2, JANUARY 11, 1888. Over two millions gross tons of Bessemer steel rails produced in 1887.

NO. 3, JANUARY 18. Our iron and steel imports in November.

A statement compiled from summary of the Bureau of Statistics, Treasury Department, showing a decline in the imports of iron and steel and iron ore.

C. R. M.

ENGINEER.

OCTOBER 14, 1887. The fastest cruisers in the world.

The Spanish cruiser Reina Regente now holds this place. The vessel on her official trial was under forced draught for four runs on the measured mile of two hours' continuous steam. The average speed was 20.6 knots. A six hours' continuous run was made under natural draught and a speed of 18.7 k. attained. Her normal displacement is 4800 tons; load displacement, 4600 tons; has a protective deck 4¾ inches thick; carries four 21-ton, six 12 cm., and twelve small guns, and has five torpedo tubes; I. H. P., 12,000.

Naval docks in China.

Chinese ships must be docked in Shanghai, Foochow, Amoy, Hong Kong, or Whampoa. The dry dock and wet basin of Port Arthur will not be available for some years to come. At Shanghai there are four large dry docks, all well fitted with machinery for effecting small or great repairs to hulls, engines, or boilers. But as all of these docks are of timber, and have been excavated from an alluvial and in general unstable soil, they are not, in our opinion, suitable for vessels which carry armor, and in consequence have their weights concentrated amidships and not distributed.

The largest dock is that of Messrs. Nicholson & Boyd at Putung, a work well built and well fitted with adequate mechanical appliances. This dock has 450 feet length on blocks, 80 feet width at entrance, with depth of water on sill at spring tides 21 feet, and at neap tides 17 feet.

The next largest Shanghai graving dock is called the "Old Dock," and is at Honkew. The length on the blocks is 380 feet, width at entrance 57 feet, depth of water on sill at spring 17 feet, and at neaps 13 feet.

There is also a dock on the Putung side, opposite the Chinese city of Shanghai, called the "Tung Ka-du Dock." The length on the blocks is 325 feet, width at entrance 70 feet, depth of water on sill at springs 16 feet. Nearly opposite to it is the dry dock of the Chinese Arsenal, which has 320 feet length, and at spring tides a depth on the sill of 18½ feet. The lower dock, nearly half way to Woosung, is only suitable for gunboats, as, though it is 345 feet long and 70 feet wide, the depth of water at the entrance is only 11 feet at high tide. If an ironclad should be placed in any of the Shanghai docks the risk would be considerable. For the cruisers and unarmored vessels the four principal docks of Shanghai would give ample accommodation.

At the Foochow Arsenal there is a wooden patent slip erected in 1870, but the timbers are now wormed and decayed so that it would not be safe to place on the cradle any but small and light vessels. Adjoining the Arsenal is a fine granite dock which could easily be lengthened so as to receive vessels of about 320 feet in length, or even a little longer.

Amoy docks are small but well placed, and have solid bottoms. The large dock could, at no great charge, be made fit to receive the Armstrong cruisers and the partially armored vessels built at Stettin in 1883.

At Hong Kong there are two large granite docks, the "Cosmopolitan" at Kowloon, and the Aberdeen at back of the island. Either of these docks can receive such vessels as the English ship Audacious or the French ship Turenne. But at the end of the year the new dock at Kowloon, one of the finest in the world, will be open and able to receive the largest, broadest, deepest, and heaviest ironclad afloat. Such craft as H. M. S. Sanspareil, weighing nearly 13,000 tons, or the Italian ship Lepanto, weighing 2000 or 3000 tons more, can be taken in easily without unloading or reducing weights.

At Whampoa there are two docks on good firm ground, with ample depth of fresh water at the edge of the dock walls, which might be again made useful. They are now much decayed. The site is excellent. The entrance to the river could be defended at Bocca Tigris, and of course there are many advantages in having a fresh water dock and anchorage. Docking iron-bottomed vessels once a year is not sufficient, and the ships of the fleet (Chinese) are, one and all, so much pitted and eroded that in a brief while the injury, which is of a most serious kind and essentially structural, will become painfully manifest. In any case, the position of Port Arthur is scarcely adequate for the Pei-yang fleet. The defensive works are admirable, but it would not be difficult to blockade the port, and few or no supplies are obtainable from the mainland. At Weihai the Chinese have an excellent position for an arsenal and docks. The harbor is good, and at the rear are all the resources of the province of Shantung. At Chiao Chow the natural advantages are very great and fit it admirably for a naval port of the first class. The basin is large, deep, and accessible; the port sheltered from wind; there is abundance of fresh water, cattle, provisions, etc., to be obtained, and at no great cost an old canal could be widened and deepened to allow the passage in all weathers of vessels of 18 feet draught from one side of the province to the other.

OCTOBER 21. The Severn.

This new fast cruiser of the Mersey class is built of steel, has displacement of 3550 tons, I. H. P. 6000; speed, 18 knots; steel protective deck. Armament is two 8-inch B. L. R. and ten 6-inch B. L. R. on Vavasseur fittings, 3 rapid fire guns, and a strong equipment of machine guns, and four Whitehead torpedo tubes. The total cost of the ship is about £240,000.

Messrs. Kirkaldy's reports on the steam pipe of the Elbe.

Contain elaborate tables of tests made of different parts of the pipe. Cause of the explosion undetermined.

The calorific value of coal.

Editorial explaining why the present method of determining this value either by the chemical formula or by the calorimeter is unsatisfactory, and suggesting further experiments.

Torpedo boats for Spain, Azor and Halcon, by Yarrow & Co.

They are 135 feet long and 14 feet beam. I. H. P. 1550. With displacement of 17 tons, one made 23.5 and the other 24 knots for 2¾ hours. The strength of the hulls is much greater than that of previous boats, the latter having been found too weak.

OCTOBER 28. The Reina Regente; illustrated; further particulars.

Length on water line, 317 feet; beam, 50 feet 7 inches; depth moulded, 32 feet 6 inches; normal displacement, 4800 tons; deep load displacement, 5600 tons; radius of action, 5900 knots at 11.6 knots per hour. A remarkable feature is the rudder of the Thompson & Biles patent. It has an area of 230 square feet, and is probably the largest ever fitted to a war ship. When the vessel was going at 19 knots it turned a half circle in 1 minute and 23 seconds, and a complete circle in 2 minutes and 58 seconds; the diameter of the circle being 350 yards.

NOVEMBER 4. Recent cruiser design.

Comparison of the Reina Regente and Aurora to illustrate the advantage to be derived by using a protective deck instead of the armor belt.

NOVEMBER 11. Calorific value of coal; editorial. Liquid fuel on the Thames.

Comparison of the oil with coal on same boat, using a new form of injector which does away with the noise generally accompanying oil burning.

NOVEMBER 18. The preservation of iron and steel ships.

While Portland cement wash has proved fairly satisfactory for inner bottoms, water ballast tanks, and such parts, a mixture of Stockholm tar and Portland cement is better. The surfaces must be free from oxidation and quite dry. They are first coated with the tar and at once sprinkled with dry cement powder as much as will stick to the tar. The tar and cement amalgamate and slowly set quite hard and waterproof. The corrosion of the metal takes place most under the engines and boilers. Uncovered decks, if not much trodden on, also corrode rapidly. Frequent scaling is better than painting with black varnish or coal tar.

DECEMBER 2.

Dr. Dieterici recently made experiments to determine the mechanical equivalent of heat by the indirect electrical method. As the result he found the mechanical equivalent to be 424.4 and 424.2 calories, these values being each the mean of a series of experiments in which the highest and lowest values found differed but little from the mean.

DECEMBER 23. Official trial of the Nordenfeldt submarine vessel. The Nordenfeldt; editorial. The strength of copper steam pipes; elaborate table of tests.

DECEMBER 30. Compound engines; editorial.

JANUARY 6, 1888. Editorial: The progress and practice of engineering.

As to the use of steel in the shape of castings and large forged masses great progress has been made in this country. Nothing stands in the way of the extended use of steel for castings instead of iron, save its cost, and that does

not, for the moment, seem likely to be reduced. It is a remarkable coincidence that, although steel crank shafts are giving great satisfaction, the experience had hitherto with steel propeller shafts of large size is not encouraging. The most noteworthy feature in marine engineering is the construction of certain new ocean steamers which are to dwarf into insignificance even such magnificent racers as the Umbria and Etruria. There are to be in all four of these. Two are being constructed by Thompson & Co., Clydebank, for the new Inman & International Co. They are to have a displacement of 10,000 tons and to be called the City of Paris and the City of New York, and one will be ready for the summer trade in 1888. They will be 525 feet long on the water line, 560 feet over all, and with beam of 62 feet. The Umbria and Etruria are 500 feet by 57 feet beam. The engines of the Umbria and Etruria are of the ordinary compound type with one H. P. and two L. P. cylinders, and have each 72 furnaces and burn about 320 tons of coal per day. The City of Paris and the City of New York will have twin screws, and I. H. P. 18,000 with forced draught. Two steamers very similar will be constructed by Harland & Wolf for the White Star Co. As the result of the use of forced draught and the triple expansion system, the grate surface in the new boats will be less than that of the Etruria, although the power will be 50 per cent greater. A remarkable ship, the Lahn, has been built for the North German Lloyd Co. She is of 5500 gross tonnage. The most noteworthy feature is the machinery. The engines are the largest triple expansion ever yet built. There are five inverted cylinders and three cranks. The ship made 19.46 knots on the measured mile and 18¾ knots on a six hours' run.

The forced draught system has made steady although slow progress during the year, and promises to have more extended adoption. The experiments carried out with the Celtic are especially interesting. She is fitted with ten boilers; two of these have been shut off, and with the remaining eight and forced draught she has kept time on her Atlantic voyage perfectly. The most remarkable improvement recently effected in boiler construction is no doubt the ribbed furnace made by Sir John Brown & Co. The furnace plates, instead of being corrugated, are stiffened by raised ribs spaced several inches apart and running around the flues.

The following steam trials of new naval vessels have taken place:

Name.	Type.	Load Displacement.	I. H. P.
Camperdown,	Twin screw armor-plated battle ship,	10,000	11,739
Anson,	" " "	10,000	12,585
Orlando,	" " cruiser,	5,000	8,739
Undaunted,	" " "	5,000	8,670
Australia,	" " "	5,000	8,876
Galatea,	" " "	5,000	9,220
Thames,	" cruiser,	3,550	5,886
Forth,	" "	3,550	5,756
Archer,	" "	1,770	3,850
Brisk,	" "	1,770	3,816
Cossack,	" "	1,770	3,700
Mohawk,	" "	1,770	3,698
Porpoise,	" "	1,770	3,944
Tartar,	" "	1,770	3,824
Fearless,	" "	1,600	3,360
Rattle-snake,	" torpedo gunboat,	450	2,872
Rattler,	Single screw gunboat,	715	1,291
Wasp,	" "	715	1,053
Lizard,	" "	715	1,023
Bramble,	" "	715	1,052
Malabar,	" troop ship,	6,211	4,230
Buzzard,	Twin screw gun vessel,	1,170	2,090

We cannot conclude our brief notice of the progress of marine engineering without alluding to the paradoxical but none the less certainly true results obtained by Mr. Kirkaldy with his apparatus for heating feed water with live steam taken direct from the boiler. [A table is given showing the saving in tons of coal claimed to be due to the fitting of these heaters on four steamships.] W. F. W.

ENGINEERING.

OCTOBER 21, 1887. Defects in the design of war ships; editorial. Steam pipe explosion on the Elbe.

OCTOBER 28. The Russian navy.

The Russian naval authorities are placing petroleum-burning furnaces in the ironclad Tchesme which is approaching completion at Sebastopol. The displacement of the ship is upwards of 10,000 tons, and her armor 16 inches thick.

The steam pipe explosion on the Elbe.

NOVEMBER 4. The Brock quadruple expansion engines; they are to work with 180 pounds steam pressure. The Elbe explosion. The engines and boilers of H. M. S. Orlando; illustrated. Defects in the design of war ships. Trials of Russian torpedo boats.

NOVEMBER 11. H. M. S. Galatea.

Twin screw armored cruiser. Measured mile speed 19 knots. Weight of machinery 770 tons, or 1.67 cwt. per I. H. P. I. H. P. 9221.

NOVEMBER 25. Engines of H. M. S. Orlando; illustrated.

DECEMBER 9. Remarkable failure of steel boiler plate made by the Witcowitz Iron Co., Moravia.

Some cracked before steam was raised, some after two days' work, and others after three months.

DECEMBER 16. Quadruple expansion engines, to work with 170 pounds steam. The bursting of the Elbe's pipe; letter to editor. A new torpedo boat. The French navy.

According to a report of M. Menard Dorian, the French navy comprises 386 [393? W.] vessels of all kinds, viz: 18 first-class ironclads, 19 ironclad cruisers, 9 ironclads used for coast guard purposes, 4 ironclad gunboats, 1 ironclad floating battery, 9 battery cruisers, 9 first-class cruisers, 11 second-class cruisers, 15 third-class cruisers, 15 first-class despatch boats, 31 second-class despatch boats, 16 despatch boats also available for transport purposes, 8 despatch boats also available as torpedo boats, 16 unarmored gunboats, 12 chaloupes each carrying a gun, 11 steam chaloupes, 10 torpedo boats for the open sea, 62 first-class torpedo boats, 41 second-class torpedo boats, 7 vedette torpedo boats, 10 first-class transports, 10 second-class transports, 4 third-class transports, 13 sailing ships, 29 ships used for fishing protection purposes, and 3 training ships. The aggregate value of this fleet is estimated at £12,741,216. The French marine has been engaged during 1887 upon the construction of no fewer than 92 vessels, viz: 8 first-class ironclads, 4 ironclad gunboats, 1 ironclad cruiser, 2 battery cruisers, 3 first-class cruisers, 2 second-class cruisers, 6 third-class cruisers, 1 torpedo gunboat, 3 despatch boats, 2 torpedo despatch boats, 54 other torpedo boats, 3 despatch boats also available as transports, 1 transport properly so called, and 2 sailing frigates. In the course of 1888 further new vessels will be undertaken to an estimated cost of £1,840,000.

December 23. Steam pipe explosion on the Elbe; report of Lloyds Chief Engineer Surveyor.

The cause was defective brazing not discoverable by the hydraulic test.

Defective designs of war ships; editorial. Disastrous boiler explosion.

Due to external corrosion where boiler rested on brickwork.

Miscellanea.

According to a German authority, the lines of a drawing made in Indian ink can be prevented from washing down in the process of coloring by mixing the ink with a two per cent solution of potassium bichromate instead of ordinary water. The potassium bichromate, under the action of light, forms an insoluble compound with the size with which the ink is prepared. W. F. W.

INSTITUTION OF MECHANICAL ENGINEERS.

October, 1886. On triple expansion marine engines.

February, 1887. On triple expansion marine engines; adjourned discussion. W. F. W.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

Volume VI, No. 11, November, 1887. Use of horizontal telescope for determining differences of latitude and longitude, by Prof. Stockwell.

Describing a new instrument and advocating its use.

Hydraulic motion.

A paper by Samuel McElroy, on modes of motion of liquids.

No. 12, December. The index department, containing 73 pp. of references to every variety of subject interesting to engineers, forms the major part of this number, and is a valuable reference list.

H. S. K.

JOURNAL DU MATELOT.

December 17, 1887. An article on the use of antipyrine as an antidote for sea-sickness.

This subject has been presented to the Academy by Mr. Brown-Séquard, and contains several experiences (60) of Mr. Eugene Dupuy, showing the effect of this medicine as taken either internally or as a subcutaneous injection.

December 31. Experiments outside the port of Havre with oil on the heavy seas.

January 14, 1888. Rockets charged with oil for use in heavy seas; invention of Mr. W. Meissel; experiments with same.

THE JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

Volume XXXI, 1887. The accuracy of field range finders. Maignen's patent filtre rapide for the use of troops. Ammunition

columns. Blockades under existing conditions of warfare. Plans of moorings protected by nettings against torpedo attack, to be utilized more especially by a blockading squadron. Suggested improvements in chart tables by Lieutenant Marx, R. N.; the table constructed by Lieutenant Ross, U. S. N., some years since, seems identical with the one here suggested. Naval reform. The new frontier of France. Recent changes in the German army. Lines of communication in modern war. Reports upon changes and progress in military matters in the continental armies during 1886. The weight carried by the soldier in European armies.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION, WOOLWICH.

VOLUME XV, No. 12, 1887. Photographic instantaneous shutters. Method of calculating trajectories. C. S. S.

MECHANICAL ENGINEER.

AUGUST 13, 1887. The steam yacht Now Then.

This vessel, considering her displacement, is the fastest in the world. No yacht, torpedo boat, or other steam craft of 81 feet length on the water line and 10 feet beam has ever achieved the same speed. Recent torpedo boats abroad have run more knots on the measured mile and made more speed for short distances, but these boats are 150 feet long, with corresponding displacements, and capacity to carry power. The Now Then has a record of 24 miles per hour for seven consecutive hours, and this on her first trip of any distance. The dimensions are: hull, over all, 86 feet; water line, 81 feet; beam, 10 feet; draft, 38 inches; displacement, 19 tons net. Engines triple expansion, Herreschoff boiler, steam pressure 250 pounds.

AUGUST 27. The Now Then.

The speed given in the previous number should have been 23.002 knots as the mean of six runs over the measured mile.

SEPTEMBER 24. Successful trial of the U. S. S. Boston.

The low speed attained is attributed to the fact that the vessel has not been docked for a year and has been lying in foul water. The excess of I. H. P. over that attained by the Atlanta is ascribed to the increased amount of coal burned per sq. ft. of grate. From 7.10 A. M. to 7.30 P. M. the engines were in continuous operation and not once slowed for heating or adjustment. There was no water carried over into the cylinders, and the temperature of the fire room was moderate, from 90° to 100° F. Air pressure, one inch of water. The maximum I. H. P. was 12.75 per sq. ft. of grate, and the average 11.34 per sq. ft. of grate. The coal used was "New River" bituminous. It was of excellent quality, but too fine to give the best results. The averages were: steam, 87.6 pounds; vacuum, 25.3 inches; revolutions, 72.3 per minute; I. H. P., main engines, 3454.82; I. H. P., auxiliary engines, 325; grate surface, 333.2 sq. ft.; mean draught, 17 feet amidship; displacement, 3041 tons; speed, 13.8 knots.

OCTOBER 8.

The Sardegna, an Italian twin screw ironclad, is to have triple expansion engines of 25,000 I. H. P., by far the largest amount afloat in any vessel. Each

screw has two sets of engines attached, one of which can be disconnected when low powers are needed.

OCTOBER 22. High speed steam launch Buzz; illustrated.

The Buzz has run over a measured mile repeatedly in 2 minutes 30 seconds, and is capable of sustaining this speed as long as the coal holds out. She can be driven at a higher speed, *i. e.* a mile in 2 min. 8 sec. The dimensions are: length, 50 feet over all; beam, 6 feet 6 inches; 4 feet 10 inches at water line; depth, 3 feet; draught forward, 9 inches; aft, 16 inches. Area of immersed midship section, 4 feet 6 inches. Boiler of locomotive type, to carry 150 pounds pressure, with forced draught in closed ash pit. Coal capacity, 1½ tons, enough to steam 800 miles at 10 miles per hour. The piston, rod, etc., are of steel. Total weight of engine complete is 703 pounds. Weight of machinery, boilers, etc., 4700 pounds. The I. H. P. is 160, or about 29 pounds per I. H. P. The I. H. P. per ton of displacement is nearly three times that ever developed in any boat afloat. The engines run at 600 revolutions without heating or pounding. The hull is made with oak frames and cedar planking. Displacement, 3½ tons. The development of the designer's (Mr. Mosher) new boat, 100 feet long, 12 feet beam, and 2000 I. H. P., will be looked for with great interest.

NOVEMBER 5. The Ariete; illustrated.

The vessel is 147 feet 6 inches long; 14 feet 6 inches beam; has twin screws and compound engines, and water tube boiler. The average pressure is 152 pounds; revolutions, 395; I. H. P. 1550; speed, 24.9 knots for two hours continuously. Builders, Thornycroft & Co., for the Spanish Government.

DECEMBER 3. Light steam engines for high speed launches; editorial. W. F. W.

THE ENGINEER (FORMERLY MECHANICAL ENGINEER).

JANUARY 15, 1888. The Chicago, U. S. N.; report of the official steam trial. (See *Prof. Notes.*) W. F. W.

MÉMOIRES DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

NOVEMBER, 1887.

This number contains an analytical discussion of the formula for condensation of vapors in terms of surface exposed and difference of temperature between surfaces.

DECEMBER.

Contains an interesting paper on the electric light companies in this country; giving a synopsis of the installations of each and their extent. S. M.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XV, NO. 11. Protection of merchant vessels during war, by Captain P. H. Colomb, R. H., United Service Institution. English fleet manœuvres in 1887. Merits and demerits of the different ways of protecting modern cruisers, by J. H. Biles (Institution of Naval Architects). Minor Notices:—The caisson of the Kowloon Docks, Hong Kong. Chinese men-of-war. Launch of the English ironclad Trafalgar. Newly launched vessel of the Imperial German

Navy. Launch of the French sailing frigate Melpomêne. Transportation by rail of a torpedo boat in France. The Russian Navy. Copying of drawings. Large steel castings. Trial firing with a new rapid firing cannon (English).

No. 12. Photogrammetrie and its uses in surveying; 2d article; treats of apparati used for getting perspectives mechanically (trikolograph and perspectograph), by Professor F. Schiffner. Advantages and disadvantages of the different kinds of armor used in modern vessels of war (from *Engineer*). Electric light on board new cruiser (Lieutenant J. B. Murdock, U. S. N.). Steel anchors and cables (from the English). Apparatus for closing water-tight doors from any place by means of electricity (from the English). Experimental firings by Krupp (from *Deutsche Heereszeitung*). Bellit (from *Revue Maritime*). Aluminium bronze for guns (from the American by Alfred Cowles). Armstrong 70-pound rapid firing cannon (*Admiralty and Horse Guards Gazette*). Launch of the French despatch boat Bengali (*Yacht*). The English turret vessel Trafalgar. New French cruisers. Notes about the Spanish navy. Yarrow's latest torpedo boat of the second class. Armored vessels for the U. S. Navy. Italian torpedo boats. Italian torpedo stations. Regulations for the Russian torpedo depot at Sebastopol. Observations for dip at sea. Desmazure's accumulator and its use on board of an electric boat in France. The fastest merchant steamers. Notes on Literature:—The German-Danish war, by the General Staff. Bretschneider's arithmetic and algebra. The Marshall islands. Charts of Africa from the time of Herodotus to the present day.

Voyage of H. M. S. Zrinyi to West India via Malta, Tangier, and Teneriffe in 1885-1886.

This is a supplement to No. 11, Mittheilungen aus dem Gebiete des Seewesens, and is written by order of the Austrian Navy Department, by Captain Jerolim Freiherrn von Benko. This book is a very complete description of the voyage of the vessel and the ports visited. It gives historical, commercial, and hydrographic information, and would be a valuable book for any who intend to visit these ports. E. H. C. L.

NORSK TIDSSKRIFT FOR SOVAESEN.

FIFTH ANNUAL SERIES, No. 5. Treatise on maritime manœuvres and exercises in the Navy, by Lieutenant Falsen. Armament of the gunboats Gor and Tyr, by Lieutenant Morch. Deviation curve, taken from the English. Captain Bergen's graphic method. Cruises of naval vessel in 1886, by Captain Larsen. Miscellaneous: The English Navy. A new English torpedo boat. English gunboats Rattler and Wasp. New torpedo boat (all from English sources). Official communications.

No. 7. Submarine boats and their use in future maritime wars (compiled from German and English sources). The new French "Bateau camera,"* (from *Cosmos*). South Polar Sea (from *Cosmos*).

* This is understood to be a description of a new class of gunboats.

Incidents during the years of war. Patriotic self-sacrifice. On changes in the present system of vessels' lights. Miscellaneous: The largest gun in the world. New governor for steam engines. The pneumatic gun in the United States. The new Spanish ironclad Pelayo. Rigging or no rigging for men-of-war. Official communications.

SIXTH ANNUAL SERIES, NOS. 1 AND 2. Theory of equilibrium of vessels, by J. S. Rasmussen, Professor of Mathematics at the Naval School. Naval organization and administration, by Lieutenant Bowesen. Jubilee review at Spithead (*Revue Maritime et Coloniale*). Sham attacks of English harbors, after *Engineering*. Miscellaneous: New American men-of-war. Brennan torpedoes. Book reviews. Official communications.

SEVENTH ANNUAL SERIES, THIRD PAMPHLET. Theory of the equilibrium of vessels, by Asst. Prof. Rasmussen; continued from last issue. How can our third-class gunboats be made useful vessels? by Premier Lieutenant Pach. The devioscope; after the English, by Lieutenant of Reserves Muller. Merchant marines of different countries, with their latest increase; from the English. Steering directions, fog signals, and stern lights; from the *Nautical Magazine*. Miscellaneous articles: The English armorclad Trafalgar. The French fleet. A Chinese squadron. The new Armstrong gun.

E. H. C. L.

REVUE DU CERCLE MILITAIRE.

OCTOBER 23, 1887. The Spanish navy. The Italian expedition to Abyssinia.

OCTOBER 30. The submarine torpedo boat Nordenfelt. Launch of the Sandfly and Spider. Reorganization of the Spanish army.

NOVEMBER 6. Torpedo boats of the English navy (tables). Experiment with optical telegraphy by means of an anchored luminous balloon.

NOVEMBER 13. Experiments in England with the magazine rifle.

NOVEMBER 20. The part taken by horse batteries in a campaign; their instruction in time of peace.

NOVEMBER 27. The same continued. The camp at Moscow.

DECEMBER 4. Photographing from a balloon, showing a photolithograph of a photograph taken. The German torpedo boats.

DECEMBER 11. The ironclad Catherine II.

DECEMBER 18. Field fortifications and the new torpedo shells.

DECEMBER 25. Field fortifications and the new torpedo shells.

JANUARY 1, 1888. Experiments in photographing projectiles during flight. The German navy at the beginning of 1888. Experiments with gelatine dynamite and rhexite.

JANUARY 8. The Alidad compass of Lieutenant-Colonel Peigné,

with plates and explanations. A new tool for use in the English army, invented by Major Underwood.

This is a species of entrenching tool which, when not in use, is worn as a breastplate, and protects up to 200 metres; its weight does not exceed two pounds seven ounces.

The maritime section devoted to torpedoes and submarine mines at Canton, China. The Italian navy at the beginning of 1888.

JANUARY 15. Russian artillery.

JANUARY 22. Replacing ammunition on the battlefield. Duels in the German army. The Nordenfelt submarine boats. Experiments in Sweden.

JANUARY 29. Fortifications as opposed to the new artillery. The military and naval schools at Tien-Tsin. The Russian fleet in the Black Sea. D. H. M.

REVUE MARITIME ET COLONIALE.

NOVEMBER, 1887. Indicator of movement or speed controller of marine engines. First attempt of the French to establish themselves in Algiers (1664). Voyage in Senegambia. Combined operations of land and sea forces. Historical studies on the French navy. Notes on Madagascar. Chronicle: English Navy: The Forth; Cruisers in the reserve; Launch of the Trafalgar; Officers of the reserve. U. S. Navy: The new American ships. Russian Navy: New ironclads. German Navy: The Ariadne. Chinese Navy: A naval division. Torpedo boats: The English cruising torpedo boat Tartar; the torpedo-dispatch boats Sandfly, Spider, and Grasshopper. Artillery: New Armstrong guns. Canals: Lighting the Suez Canal; the Manchester Canal. Engines: Instantaneous production of steam. Navigation: New routes of communication with the far East.

DECEMBER. The railroads of Tonkin. Combined operations of land and sea forces. Voyage in Senegambia. Campaign of Rio Janeiro during 1711. Chronicle: Spanish Navy: The Reina Regente. U. S. Navy: The Buzz, steam launch of great speed. Artillery: The American pneumatic cannon. Canals: The Interoceanic Nicaragua Canal. Geographical: Thursday Island. Engines: Quadruple expansion. Harbors: The dry dock at Esquimault. Life saving: A new life boat. Telephonic communication between boats. Torpedo boats, new type of small. Voyages: English exploration of the South Pole.

JANUARY, 1888. Notes on Madagascar. The Brennan torpedo. Tonquin in 1883. Voyage in Senegambia. Chronicle: The German cruiser Princess Wilhelm. Loss of the English gunboat Wasp. Trial of the Galatea. The gunboat Bramble. Defense of coaling stations. New (U. S.) system of coast defenses. Russian gunboats, type Terets. Black Sea cruisers. New Turkish ships. New method for preserving iron and steel keels. The shell of the U. S. pneu-

matic gun. Shells charged with anaesthetic compounds. Wire wound guns. English rapid-fire guns. New type of English torpedo. Cannon on disappearing carriages. Plans for new (U. S.) torpedo boat. Trial of the submarine torpedo boat Nordenfeldt. The Berdan torpedo and the Zalinski shell. D. H. M.

REVISTA MARITIMA BRAZILEIRA.

JULY TO SEPTEMBER (inclusive), 1887. Experiments with oil at the shipwreck of the Rio Apa, which was lost on the bar of the Rio Grand do Sul; also in the case of the steamer Moidart in the roads of Madeira; the Emily F. Whitney caught in a hurricane, and of the Palos on her trip from Nagasaki to Yokohama. The English navy. External ballistics, preliminary definitions. Krupp and de Bange compared. Organization of the meteorological service in Europe. An article on the use of oil, by Lieutenant Affonso Livramento, of the Brazilian navy.

OCTOBER. External ballistics, movements of oblong projectiles. The English navy. Theory of submarine mines, by Friedrih Jedhczaka. Notice to navigators. D. H. M.

RIVISTA DI ARTIGLIERIA E GENIO.

NOVEMBER, 1887. Fortifications and siege operations: Defensive war; forts; factors of resistance; type of works; general plans of forts; line of fire; security and solidity of forts; mountain defense; coast defense. Summarized description, with plans, of the military school at Messina. Indirect firing in field artillery practice. Article on Italian field artillery. Notices: Italy; cable traction on canals and rivers. Austria: adoption as an infantry arm of the Mannlicher 8 mm. rifle. Belgium: experiments in aerial-electric signalling at Antwerp.

DECEMBER. Relation between charges and initial velocity; a mathematical essay. The Maxim gun, with description and plates; comparison of the Gardner, Gatling, Nordenfeldt, Hotchkiss, and Maxim guns. Historical sketch of the progress of aeronautics. Continuation of article on Italian field artillery. J. B. B.

RIVISTA MARITTIMA.

NOVEMBER, 1887. The Black Sea: a military, geographical study of this body of water, the Sea of Marmora, and the connecting straits; containing hydrographic and meteorological information, details of topography of coasts, and particulars of fortifications. By Géza dell' Adami, lieutenant in the Austro-Hungarian navy.

Petroleum as fuel in torpedo boats. Reproduction of article in *Le Génie Civil*, of Paris, by M. Jules d'Allest, chief engineer of the Fraissinet Company of Marseilles. With plates.

Description of the sprayer. Volume of air necessary to combustion. Volume of the products of combustion. Comparative powers

of evaporation of coal and petroleum. System of boilers and oil tanks. Substitution of compressed air for steam in atomizing the petroleum. Article on Saigon and the French colony of Cochin China.

DECEMBER. Historical account of services of Italian seamen under the Spanish flag. Coral fishing on the Sciacca bank. The submarine fauna of the Gulf of Naples. Powders used in Russia, Germany, France, Austria, and Italy, for guns of various calibres.

A brief description of the various powders used, with tables containing dimensions and weights of guns, shape of powder grain, dimensions of grains and their number per kilogram, absolute density, weight of charge, proportional weights of charge and projectile, weight of projectile, initial velocity, and maximum pressure of gases of combustion.

Notes on some cannon manufactured at Elswick, with tables of dimensions and weights of the 16.25-in., the 10-in., 8-in., 6-in. breech-loaders, and the 9.27-in. and 6.3-in. muzzle-loaders. Classified list of vessels of the Italian navy, with their stations, up to Jan. 1, 1888.

J. B. B.

TRANSACTIONS OF AMERICAN SOCIETY OF CIVIL ENGINEERS.

VOL. XV, JUNE, 1887. Steel: its properties; its uses in structures and in heavy guns. By William Metcalf, M. Am. Soc. C. E. With discussions.

This paper and the discussions, being such a valuable addition to the literature of ordnance, an extensive review of them will be published in the next number of the Proceedings.

A. M. K.

TRANSACTIONS OF THE NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

VOL. III, SESSION 1886–87. On the use and transport of liquid fuel. Compound versus triple expansion engines.

These two articles are so full of valuable and detailed information that an abstract could not do them justice.

W. F. W.

THE UNITED SERVICE GAZETTE.

OCTOBER 29, 1887. The loss of the Wasp. Indirect musketry fire.

NOVEMBER 5. Thursday Island as an English coaling station.

NOVEMBER 12. Collisions at night and color blindness. Armed merchantmen—a sham. Why not a strong Channel squadron?

NOVEMBER 26. Underground rifle ranges.

DECEMBER 10. Armstrong ordnance.

Giving views of 11-inch howitzer on hydro-pneumatic disappearing carriage; 25-pounder elephant gun; 6-inch gun on a hydro-pneumatic disappearing carriage, showing the method by which it is proposed to protect a seacoast; also, 36-pounder improved Elswick gun on a Vavasseur automatic centre-pivot carriage.

DECEMBER 24. Attack formations and fire tactics. The Nordenfeldt submarine torpedo boat.

JANUARY 7, 1888. Military events in 1887. Naval retrospect, 1887.

JANUARY 14. (Supplement.) Mr. T. Nordenfeldt's lecture on quick firing guns in the field. D. H. M.

LE YACHT.

OCTOBER 29, 1887. P. 400: Many interesting articles about foreign navies.

NOVEMBER 5. P. 409: French naval chronicle. P. 412: The Normand torpedo boat. P. 413: The Dupuy-de-Lome.

NOVEMBER 12. P. 417: Drawings and description of the boilers of the Spanish torpedo boat Ariete.

NOVEMBER 19. Pp. 427, 428: Drawings and description of the Spanish cruiser Reina Regente.

NOVEMBER 26. Pp. 432, 433: Numerous interesting foreign items. P. 435: Drawings and description of the Russian torpedo boat Wiborg.

DECEMBER 3. P. 440: Normand torpedo boats. The throwing of oil on the sea; its effect on the parts not protected by the oil.

DECEMBER 10. P. 449: Progress of electricity as applied to navigation. P. 452: English cruising ironclads, type the Orlando.

DECEMBER 17. P. 455: Officers of the Reserve (naval). P. 456: The new twin-screw transatlantic packet boats. The Russian ironclad Sinope. P. 457: History of the use of oil on the sea.

DECEMBER 24. P. 464: Foreign chronicle—many interesting items. P. 465: The Buzz plan and description of this new U. S. steam launch.

DECEMBER 31. P. 472: Electric boats for the French navy. P. 473: New steamers of the Inman Line. P. 476: Experiments with oil in heavy seas, on board the steamer Ville de Montevideo.

JANUARY 7, 1888. P. 1: The navies in 1887. P. 3: The submarine Nordenfelt boats. Progress of marine engines. P. 4: Plans and description of a U. S. armored cruiser. P. 7: Yachting in the U. S.; organization of a Naval Reserve. P. 10: The use of oil at sea; report of the Prince of Monaco on experiments conducted on board his yacht, the Hirondelle.

JANUARY 14. P. 13: Organization of the French naval forces under the new Marine Minister. P. 19: Launch of the 3d class cruiser Le Forbin.

JANUARY 21. P. 23: Ship designed by Rear-Admiral Pallu de la Barrière (being continued from p. 14 of the preceding number), giving plans and description. P. 27: Experiments with oil on board the Werra.

JANUARY 28. P. 32: View of the Tage. P. 34: Experiments with a steam life-boat on the Neva.

This boat was filled with water, was cleared in five minutes, but the furnace was so well protected that the fire was not affected by the water.

D. H. M.

REVIEWERS AND TRANSLATORS.

Lieut.-Commander C. S. SPERRY,
Lieut. E. H. C. LEUTZE,
Lieut. J. B. BRIGGS,
Lieut. D. H. MAHAN,
Lieut. A. M. KNIGHT,
Lieut. J. T. SMITH,
Prof. C. R. SANGER,
P. A. Engr. W. F. WORTHINGTON,
Ensign H. S. KNAPP,
Ensign S. MORGAN.

ANNUAL REPORT OF THE SECRETARY AND TREASURER.

TO THE OFFICERS AND MEMBERS OF THE INSTITUTE.

Gentlemen :—I have the honor to submit the following report of the business transactions of this office for the year ending December 31, 1887.

ITEMIZED CASH STATEMENT.

RECEIPTS.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Dues	$637.03	$602.50	$423.00	$244.23	$1,906.76
Subscription	136.40	20.65	501.25	103.75	762.05
Sales	455.24	208.91	85.13	150.97	900.25
Life-membership fees	174.00	90.00	90.00	90.00	444.00*
Interest on bonds	33.63	....	27.25	20.86	81.74
Binding, extra	9.25	9.70	9.80	18.50	47.25
Sundries	....	1.70	5.63	3.00	10.33
Total	$1,445.55	$933.46	$1,142.06	$631.31	$4,152.38

* Six ($6) dollars must be credited to this amount from the balance of cash brought forward from 1886 on account of two years' advance dues paid by a regular member who afterwards became a life member.

EXPENDITURES.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Postage, freight, telegraphing, and incidentals	$66.02	$83.14	$45.56	$44.45	$239.17
Stationery at H. Q.	57.50	8.75	11.16	9.55	86.96
Messenger at H. Q.	65.00	80.00	90.00	108.00	343.00
Branch expenses	24.45	5.40	3.78	9.86	43.49
Extra binding	67.00	10.50	5.50	38.70	121.70
Purchase of back numbers.	23.50	....	....	6.50	30.00
Prize for 1887	....	102.50	....	....	102.50
Publications	935.55*	500.00	533.70	897.87	2,867.12
Purchase of bonds	244.00	....	122.75	119.25	486.00
Rebate on sales, etc.	15.65	4.53	3.00†	225.00‡	248.18
Advertising	99.95	....	....	....	99.95
Office expenses H. Q.	50.00	3.95	2.60	6.54	63.09
Total	$1,648.62	$798.77	$818.05	$1,465.72	$4,731.16

* This amount includes that paid for Whole No. 39, which was issued in December, 1886.

† Money order made out payable at Washington returned.

‡ To War Department on account of duplicated subscriptions.

SUMMARY.

Balance of cash unexpended for year 1886	$730.17
Total receipts for 1887	4,152.38
Total available cash for 1887	$4,882.55
Total expenditures for 1887	4,731.16
Cash unexpended January 1, 1887	$151.39
Cash held to credit of Reserve Fund	112.12
True balance of cash on hand January 1, 1888	$39.27
Bills receivable for sales of No. 43 and reprints made late in December,	205.00
Bills receivable for back dues	823.00
Total assets January 1, 1888	$1,067,27
Bills outstanding for balance due on No. 43 and reprints	149.85
Excess of assets over liabilities	$917.42

RESERVE FUND.

On the first day of January, 1887, there were deposited to the credit of the Reserve Fund in the Farmer's National Bank of Annapolis, Md., for safe keeping, the following bonds: $900 four per cent. consols, registered; $1000 District of Columbia 3.65 per cent., registered, and $350 District of Columbia 3.65 per cent., unregistered; making a total of $2250 (face value). There was also an uninvested balance to the credit of the Reserve Fund of $148.12 at the beginning of 1887. During the year 1887 the Institute acquired 15 new life members whose fees amounted to $450, thus making $598 to the credit of the Reserve Fund for the year. In accordance with Art. VIII. of the Constitution, $486 of this amount was invested in District of Columbia 3.65 per cent. bonds, representing a face value of $400. The total face value of the bonds held by the Institute to the credit of the Reserve Fund on January 1, 1888, is, therefore, $2650, leaving an uninvested balance in cash of $112.12.

The annual interest on these bonds, amounting to $99.88, is available for current expenses, the principal being held in perpetuity to guarantee the life members' interests in the Institute.

MEETINGS AND PUBLICATIONS.

During the past year nine meetings of the Institute were held at Annapolis, one at the Washington Branch, two at the Newport Branch, and one at the Norfolk Branch.

The quarterly publications were issued as follows: Whole No. 40 in February, whole No. 41 in May, whole No. 42 in August, and whole No. 43 in December. These numbers formed a volume (No. XIII.) comprising 709 pages, not including the Appendix, notices, and plates. During the year the scientific value of these publications found ready recognition, not only among the students of naval and military science, but also among a large number of prominent civil and mechanical engineers, metallurgists, and chemists, both at home and abroad, and we may well take pride in the fact that our quarterly now ranks among the first of the scientific journals of the United States.

In connection with the subject of publications, it may be well to state that, owing to a lack of funds, the Board of Control had to decline during the past year the publication of several papers that would have proved of much interest could they have been printed. An inspection of the summary of the cash statement accompanying this report will show a large amount of dues in arrears at the end of the year 1887. Could this amount have been at the disposal of the Board of Control at the beginning of the year, over 300 pages of interesting matter might have been added to the Proceedings. The prompt payment of all dues in advance at the beginning of each year, as called for by the Constitution, Art. VII., Sec. 8, would obviate this difficulty by insuring a fund upon which the Board could make their estimates in advance for the entire yearly publication. All members, therefore, are requested to give this matter their serious consideration.

Publications on Hand.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

	Copies Plain.	Copies Bound.		Copies Plain.	Copies Bound.
No. 1	211	...	No. 10	9	...
2	254	...	11	226	...
3	70	...	12	66	...
4	162	...	13	10	...
5	132	...	14	8	...
6	15	...	15	3	...
7	21	...	16	230	...
8	46	...	17	2	...
9	50	...	18	99	...

	Copies Plain.	Copies Bound.		Copies Plain.	Copies Bound.
No. 19	114	...	32	...	181
20	133	...	33	19	165
21	238	...	34	64	11
22	282	...	35	110	67
23	188	...	36	251	29
24	207	...	37	177	24
25	1151	44	38	225	4
26	211	77	39	263	4
27	298	27	40	51	113
28	3	1	41	276	21
29	231	27	42	171	20
30	261	4	43	186	4
31	63	56			

1 full set bound in half morocco.
4 Vol. X., Part 1, bound in half morocco.
1 " " 2, " " " "
2 of No. 34, " " " "
9 " " " " full sheep.
8 " " " " half calf.

The archive set complete, Vol. I. to Vol. XIII. inclusive, bound in full turkey.

MEMBERSHIP.

The membership of the Institute to date (March 1, 1888) is as follows: Honorary members, 7; life members, 86; regular members, 573; associate members, 165; total, 831, showing a net increase of 44 members since the last lists of members were published (March, 1887). During the year there have been eleven deaths and five resignations.

The names and addresses of the members that have joined the Institute since March, 1887, are given in the following lists:

Life Members.—12.

* Bicknell, G. A., Lieutenant-Commander, U. S. N.

* Burgdorff, T. F., Assistant Engineer, U. S. N.

Cannet, Gustave, Ingénieur Chef du Service d'Artillerie de la Ste. des Forges et Chantiers de la Mediterranée, 1 rue Vignon, Paris, France.

Carington, H. S., Secretary, Sir Joseph Whitworth & Co., Limited, Openshaw, Manchester, England.

* Transferred from list of Regular Members.

Case, A. L., Jr., No. 219 Benefit Street, Providence, R. I.
Gledhill, M., Manager, Sir Joseph Whitworth & Co., Limited, Openshaw, Manchester, England.
† Hutchins, C. T., Lieutenant-Commander, U. S. N.
* Jackson, J. B., No. 126 East 35th Street, New York, N. Y.
* McCrackin, Alex., Lieutenant, U. S. N.
Metcalf, William, Pittsburgh, Pa.
Pinn, J. F., Japan Herald, Yokohama, Japan.
* Wood, Spencer S., Ensign, U. S. N.

Regular Members.—16.

Bailey, F. H., Passed Assistant Engineer, U. S. N.
Baxter, W. J., Assistant Engineer, U. S. N.
Chase, V. O., Ensign, U. S. N.
Clark, N. B., Chief Engineer, U. S. N.
Haywood, Charles, Colonel, U. S. M. C.
Henderson, Richard, Lieutenant, U. S. N.
Hodgson, A. C., Lieutenant, U. S. N.
Lasher, O. E., Lieutenant, U. S. N.
Low, W. F., Lieutenant, U. S. N.
Pemberton, J., Passed Assistant Engineer, U. S. N.
Peters, G. H., Lieutenant, U. S. N.
Skelding, Henry T., Paymaster, U. S. N.
Very, S. W., Lieutenant-Commander, U. S. N.
Williams, C. S., Ensign, U. S. N.
Wyckoff, Ambrose B., Lieutenant, U. S. N.
Young, Lucien, Lieutenant, U. S. N.

Associate Members.—38.

Abbot, Henry L., Colonel and Brevet Brigadier-General, Engineer Corps, U. S. A.
Aspinwall, William H., No. 25 East 10th Street, New York.
Camera, Manuel de La, Captain, Spanish Navy, Naval Attaché, Spanish Legation, Washington, D. C.
Canfield, A. Cass, Commo. S. C. Yacht Club, No. 60 W. 54th Street, New York.
Collins-Stanforth, F. S., Union Club, New York.
Cowles, Alfred H., McRea Block, Lockport, N. Y.
Cowles, Eugene H., No. 47 Windsor Street, Cleveland, Ohio.
Davin, A., Lieut. de Vaisseau de la Marine Française, Paris, France.

* Transferred from list of Regular Members. † Prize Essayist, 1887.

D'Oremieulx, L. F., Secretary, S. C. Yacht Club, No. 7 East 32d Street, New York.
Drayton, Percival L., Union Club, New York.
Edison, Thomas A., Orange, N. J.
Gaskin, Edward, No. 878 West Avenue, Buffalo, N. Y.
Hale, Irving, 1st Lieutenant, U. S. Engineer Corps.
Hall, Henry P., Sheffield Scientific School, New Haven, Conn.
Howland, M. Morris, University Club, New York.
Krupp, Fried., Essen, Germany.
Leavitt, E. D., No. 2 Central Square, Cambridgeport, Mass.
Lee, C. S., Union Club, New York.
Lotin, Captain, French Army, Military Attaché, French Legation, Washington, D. C.
Lyman, Thomas C., No. 8 East 65th Street, New York.
McClellan, William B., Secretary, Dorchester Yacht Club, No. 52 Monadnock Street, Dorchester, Mass.
MacMurray, J. W., Major, U. S. A., Presidio, San Francisco, Cal.
Meatyard, E. B., Lake Geneva, Wis.
Mendenhall, T. C., President, Rose Polytechnic Institute, Terre Haute, Ind.
Metcalf, Henry, Captain, U. S. A.
Otis, Charles A., Otis Steel Manufacturing Co., Cleveland, Ohio.
Peck, Chas. F., Dwight Place, Englewood, N. J.
Richards, Joseph W., M. A., A. C., Lehigh University, South Bethlehem, Pa.
Shibayama, M., Captain, I. J. N., Naval Attaché, Japanese Legation, Washington, D. C.
Snow, J. H., General Superintendent, National Transit Co., No. 26 Broadway, New York.
Stephens, William P., Yachting Editor, *Forest and Stream*, No. 39 Park Row, New York.
Stevenson, Charles A., No. 57 Beaver Street, New York.
Stewart, W. A. W., No. 49 Wall Street, New York.
Tams, J. Fred., Fleet Captain, S. C. Yacht Club, No. 76 Wall Street, New York.
Uberroth, Preston H., Lieutenant, U. S. R. M.
Waldo, Leonard, Dr., Electrical Engineer, Scoville Manufacturing Co., Waterbury, Conn.
Washington, Henry S., A. B., S. F., No. 174 Orange Street, New Haven, Conn.
Woodbury, John McGaw, M. D., No. 120 5th Avenue, New York.

MEMBERS DECEASED SINCE MARCH 1, 1887.—11.

William Denny, Dumbarton, Scotland.
Lieutenant John W. Danenhower, April 20, 1887.
Surgeon Horatio N. Beaumont, April 30, 1887.
Chief Engineer H. L. Snyder, June 30, 1887.
Chief Engineer W. L. Nicoll, July 2, 1887.
Chief Engineer W. D. Smith, Sept. 11, 1887.
Rear-Admiral J. R. M. Mullany, Sept. 17, 1887.
Passed Assistant Paymaster W. C. McGowan, Dec. 25, 1887.
Rear-Admiral C. H. Wells, Jan. 28, 1888.
G. Willamov, Russian Consul-General, Roumania, Feb., 1888.
Chief Engineer H. S. Davids, Feb. 8, 1888.

Before concluding this report, I wish to acknowledge my indebtedness to the various Corresponding Secretaries for the cordial and efficient assistance they have rendered me in conducting the business affairs of this office during the past year. Much of the present prosperity of the Institute is undoubtedly due to the gratuitous and oftentimes very arduous duties performed by these gentlemen, and too much credit cannot be given them for the faithful and zealous manner in which they have always guarded the interests entrusted to their care.

Very respectfully,

CHAS. R. MILES, *Lieut., U. S. N.,*
Secretary and Treasurer.

ANNAPOLIS, MD., *March* 1, 1888.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1889.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor must send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1889. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges shall be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay shall be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, may be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Defense of the Atlantic and Gulf Coasts of the United States.*

7. The essay is limited to seventy-two (72) printed pages of the Proceedings of the Institute.

8. All essays submitted must be either type-written or copied in a clear and legible hand.

9. The successful competitor will be made a Life Member of the Institute.

10. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

CHARLES R. MILES,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *March* 1, 1888.

Vol. XIV., No. 2. 1888. Whole No. 45.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XIV.

EDITED BY
Geo. W. Tyler, Chas. R. Miles,
W. F. Worthington.

PUBLISHED QUARTERLY BY THE INSTITUTE.
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The writers only are responsible for the contents of their respective articles.

CONTENTS.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XIV., No. 2. 1888. Whole No. 45.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES FROM THE JOURNAL

OF

LIEUTENANT T. A. M. CRAVEN, U. S. N.

U. S. S. DALE, PACIFIC SQUADRON,

1846-49.

II.*

January 29, 1847.—Sailed from Monterey for Panama, via Santa Barbara, San Pedro, and San Diego, three small ports on the coast of Upper California, into each of which we peeped, and in none found anything of note save at San Diego where the Congress was lying at anchor. The passage to Panama was long and tedious; we arrived March 15, and left on the 28th for Monterey, and reached the latter port May 23, finding the Columbus and Warren and several trading vessels at anchor. The place is busier and more active than when we left; indeed, then it had the appearance of a deserted village; now it begins to show some signs of life and activity; quiet has been restored, people have returned to the cares of their affairs, and the

* Concluded from No. 44, p. 148.

increase of our squadron, with the arrival of troops, stores and munitions of war, all cause quite a stir in the little town. The country around is now decked in all its beauty; endless varieties of flowers, of the gayest colors, cover the hillsides and valleys. Acres upon acres of lupines, yellow, white, blue, purple, and variegated, of all tints and descriptions, may be seen, whose tops are higher than my head when on horseback—say eight feet high. How rich and beautiful they are!

I went on a deer hunt last week with a small party, mustering five in number. We left the town about noon, and rode some fifteen miles through the most lovely country, when we reached a romantic spot in a deep glen, a basin, from which flowed a stream of delicious water. A deserted Indian wigwam stood under some magnificent trees, and here we resolved to encamp for the night. Before our camp-fire was lighted, one of our party brought in a fine buck, which was soon dressed in hunter's style, and there on the grass we supped and slept in quiet. We kept our fire through the night, and as day dawned breakfasted, mounted our steeds and started for the chase. After a weary day's ride I returned to the ship quite satisfied with my first hunt. I had but one shot, and as is the case with all on first seeing a deer, I stopped to look for a moment at the graceful animal as it bounded off, and on coming to my senses, fired without dismounting from my horse, and the deer kept on unharmed.

June 10.—One who has never seen the Spaniards nor the descendants of that proud race can have but little idea of the state of degradation to which they are now reduced. As I look upon them in the various parts of the world where we have met, a feeling of melancholy always comes upon me. The haughty Spaniard is sunk beneath the yoke of superstitious tyranny and ignorance, till, bruised as he is, you cannot recognize in him the son of that fair land once glorious in the pages of history. These reflections have come upon me while considering the condition of the degraded race who have possessed this California soil, and from whom it has now been wrested by the descendants of the Anglo-Saxon.

California is a beautiful country, well adapted for grazing, and its valleys should abound in fertility; but the people have been so lazy, their method of cultivation so slovenly, that but little more has been reaped than the natural productions of the soil, and scarcely the half of that. Cattle run wild and fatten on the oats which abound in the mountains; immense droves of horses are seen in the plains; but the

slothful son of Mexico, wrapped in his *serape*, lounges about the streets with his cigareta in his mouth, puffing away care and forgetting that he is human. Too lazy to work, he robs the industrious and spends his ill-gotten gains in the gambling house.

Here we are in the bay of Monterey. Beef is plenty, because it will thrive without care, but our own men have to kill it. Vegetables are an unknown luxury; beef and bread from one year's end to the other; a few miserable cabbages are brought in and sold for 12½ cents each; a small mess of beet tops brings the same price—and these are all the vegetables. Some of the Americans lately settled here have planted gardens and will soon enjoy abundant returns. The Mexican looks on in contemptuous silence and puffs his cigareta, or mounting his steed, dashes off like the wind and, like the Arab of the desert, imagines himself lord of the soil. There was no money in the country before we came; business was carried on by trade. The rancheros came to the seaport to buy clothing, etc., bringing with them hides and tallow. A hide worth one dollar and a half would purchase a yard and a half of calico, and that is the way they have lived. Money is now more plentiful, and the necessaries of life are becoming cheaper, but still the discontented Mexican shrugs his shoulders and wishes for a change, though that change be a relapse into the recent poverty and degradation of the place. The truth is the natives are impatient of law and order; so long have they been turbulent and unruly that they cannot bear the restraints which wholesome government will impose upon them.

I was much struck with the contrast between our own race and the Spaniard the other day while on my walk on shore. I went to a brickyard just started by three industrious Americans, who, with two boys, were hard at work and seemed to have no time to talk. They make 4000 bricks per day, and expect to burn a kiln of 100,000 per month; have already got orders for 300,000 bricks at $15 per thousand. I now went to an adjoining place where, after the manner of the ancients, two lazy Californians, who worked as if they had a thousand years ahead of them, were making adobes. Full glad were they to drop their work and talk. I asked how many adobes they made in a day. "Two hundred in a long day." "And what are they worth?" "Two dollars a hundred." Here, said I, is the Spaniard in contrast with the descendants of the enterprising Saxon. The former makes bricks as the Israelites made them in Egypt, and earns two dollars per day; a Yankee, within one hundred

yards of them, makes bricks as Yankees make them and earns more than five times the amount, while making a better and more durable article.

June 22.—Arrived at Saucelito, bay of San Francisco, and on July 18 sailed for Monterey, and had hardly anchored there ere summoned away to the southward. A revolt had broken out among the troops at Santa Barbara, and the Governor went down in our ship to suppress it. On arriving we found that the affair had been greatly exaggerated. Some trivial offenses had been committed, and the culprits were brought before a court-martial for trial and punishment; meanwhile we spent a week tolerably pleasantly, as the change from Monterey was agreeable. The town of Santa Barbara, like the other settlements of California, consists of a few scattered houses of adobe with tiled roofs, built without regard to regularity or comfort, filled with fleas and other vermin; the idle inhabitants loitering about or riding at full gallop through the place. It is built on a plain, about one mile distant from the shore, which here forms a slight curve. The anchorage is safe in the summer, but during the stormy seasons of the year it is very insecure. The population is about 1000. There was formerly a most flourishing missionary settlement at Santa Barbara, but here, as elsewhere in California, the power of the priests has been destroyed by the grasping hand of the government, and the missions, which brought such boundless wealth to the church, are now heaps of ruins. The summer droughts parch and burn all vegetation, and no kind of summer cultivation is successful without expensive irrigation.

The discontent among the troops having been adjusted by a court-martial, we left Santa Barbara five days after arrival, with three of the malcontents as prisoners on board, to be conveyed to Monterey, there to be put at hard labor in the chain-gang for three months.

Nothing of importance transpired until the 6th of September, when, in company with the Congress, we sailed from Monterey for the Gulf of California; the Portsmouth had preceded us by two days, and the rest of the squadron was to follow in October. On the 19th we touched at San José, and on the same day fell in with the Portsmouth; in the evening the three ships separated, our own standing up the Gulf for La Paz, where we arrived on Wednesday the 23d.

La Paz is a small settlement at the head of a fine bay of that name. It is now occupied by our troops, two companies of New York volunteers having been sent down in the Lexington. A rumor had

reached this place to the effect that Mexican troops were assembling at Mulejé, a small town opposite Guaymas, and without delay we again got underway and stood out to sea, bound up the Gulf. We sailed on the evening of Sunday the 26th, and on the following day at evening anchored at Lorěto, some eighty miles below the place of our destination. Here the report was confirmed, and we were told that two hundred Mexicans had landed and were organizing a force to march upon La Paz and wrest it from our hands. The chief instigator in the insurrection is the priest attached to this last place, who has left his flock at Lorěto and gone to Mulejé. To this place we hastened, and arrived September 30.

This was a memorable day in my naval career. In the afternoon I was sent on shore with a flag of truce, and was met by an officer from the town, about three miles distant; or I should say I was sent to meet him, for he was already there with a white flag. Our ship was under English colors. A few moments after I left the ship our colors were shifted and the American ensign floated gaily in the breeze. My friend with the white flag, at this sight, dashed spurs in his horse's side, and never was flight more rapid. I kept on to the beach, and finding no one there to receive me, had time to look around to see what could be done. Crossing over a neck of land, I came to the creek and took a look at a schooner at anchor there; I also directed the boat to pull around to the creek. The officer with the flag of truce was now seen at a distance slowly riding toward us, and I started to meet him. On approaching, he demanded in the name of the military commandant of Mulejé the cause of our visit. I replied that we had come to ascertain the disposition of the inhabitants. To this he said that his commandant had directed him to say that any communications with him must be protected by a flag of truce, which would be respected, but on no other occasion must our boats enter the creek, or they would be fired upon. I laughed, and answered that it would give us pleasure to be so received, but that it was a strange attitude for them to assume; we regarded the Californias as American territory, and wished to protect the inhabitants; we desired peace—had issued proclamations promising quiet and liberty, both civil and religious, to the people; the country was in our possession, and all resistance was in vain. "If you place yourselves voluntarily in arms against us," said I, "the consequences must rest with yourselves; I am coming into this creek, and if you fire upon me I will punish you." After some further conversation of little consequence

we parted, and I returned to the ship to make my report, asking permission to carry in our boats and bring out the schooner. While we were engaged in making preparations for this expedition, the officer with the white flag again made his appearance on the beach. I went to meet him the second time, and found that he had been sent by his commandant to ask if there were any reply to his communications of the morning. I told him No; his commandant had taken up arms and sent off a threat to fire upon us if we came in; that we should therefore act accordingly; his hostile message admitted of no reply; come into the creek we would. "But, Señor," said he, "we are bound to defend our country, and American jurisdiction has never extended to this place." "That is all very well," said I; "you are to be regarded either as friends or enemies; lay down your arms and we treat you as friends, but if you commit any violence we punish you." Seeing that he was disposed to have a long talk, I suspected that it was to gain time for some object the Mexicans might have in view, therefore I cut short our interview and returned to the ship to lead in the boats.

Having manned and armed all the boats, we pushed off and pulled into the creek. On boarding the schooner she was found to be deserted and scuttled, with two feet water in her hold and sinking fast. While a part of my men were landed on the beach to cover the cutting out party, others earnestly set to and plugged up the holes in her bottom, threw overboard a large portion of her ballast, bailed and lightened her, weighed her anchors, ran out warps and hauled her out of the creek. Meanwhile the Mexicans assembled in large parties on the hills, but kept at a very respectful distance. When the schooner was fairly out of the creek all our parties embarked, and as we pulled off the enemy came down gradually until they reached the beach, but offered no violence, so we carried out the prize, my first, without accident.

October 1.—In the morning I was despatched with a flag of truce to demand of the forces on shore their arms, a pledge of neutrality and non-intercourse with Mexico during the war. An officer met me; I delivered my communication for his commandant, and gave him three hours to decide. I must go back a little. On returning to the ship last night I asked the captain to give me a party to land and disarm the people. His answer was undecided, but I gained some encouragement. When I was going on shore in the morning he told me to allow them twelve hours to decide on their course. I

suggested that they had already been twenty-four hours thinking about it, as we had conferred with them yesterday. "Well," said he, "give them three hours." Having delivered my communication, I returned to the ship and we began busy preparations for a landing.

Meanwhile the captain called a council of war. Three lieutenants were assembled in the cabin, and our respective opinions asked as to the course to be adopted. I need not say we urged stringent measures for subduing the enemy and bringing him to terms. While yet in council a flag of truce was reported on the beach, and I was again despatched to meet my friend. The reply he brought was in writing, a mixture of bombast and defiance. So to arms was the order. Our boats were soon manned, and at 2 P. M., leaving the ship, I landed within the creek with eighty officers and men. My associates were Lieutenant Wm. T. Smith, Lieutenant Tansill of the Marines, Passed-Midshipman James M. Duncan, and Midshipmen Thomas T. Houston, J. R. Hamilton, and W. B. Hayes. I sent the launch up towards the town to join me there; about the same time the ship opened her batteries on the town, but it was too distant for her shot to make any impression. Having formed my men on the beach, we marched toward a hill on which a body of Mexicans had posted themselves and where we expected to have a fight. We had not proceeded far, however, when we were fired upon from a house and thickets on our left. I immediately detached a party to burn the house and drive the enemy out, while I with the rest of my force charged upon the thickets, which we passed through without encountering the unseen foe. The house was soon in a blaze, and on we marched for the hill. When we reached a height which commanded the hill, I passed an order to the following effect: "Men, we are to go to the top of that hill. If we are fired on in ascending it will break our order, as the hill is so steep. As soon as the fire of the enemy commences, let the word be, 'Every man for the top of the hill; he who reaches it first is the best man.'" The heat was excessive, and the pathway, through thorny acacia and prickly cacti, so steep that we could scarce keep our foot-hold; but up we went and gained the summit—the bird had flown, without awaiting our approach. I commanded a halt to rest the men, and while drawn up, with arms at rest, the enemy, in earnest, opened a fire upon us from several places of ambush; the balls whistled about us merrily, and in return we sent among them, in the bushes and behind the rocks, a shower of lead which soon started

them out up the banks of the creek. Down the hill we went to march through the town, and thus drew upon ourselves a hot fire again. The launch had now come up, and I ordered her to riddle some houses on the bank of the stream from which the enemy was firing. Our balls drove them from the bushes, and away they sped to the hilltops. Further pursuit was useless, and I commanded a homeward march for the ship. We drew off without the loss of a man and returned to the ship; two were wounded slightly, and it is supposed we killed many of the enemy, as our fire upon them was in heavy volleys. At daylight the next morning we sailed, as the weather had a threatening appearance and our anchorage was insecure; we had the prize in tow, but as it was a heavy drag upon us, towards night we fired her, and as darkness came on the burning vessel beautifully lighted up the horizon. On our way down we touched at Loréto and also at Descondido, and on Friday, October 8, again anchored at La Paz.

I had applied to the captain to give me a small schooner belonging to an American at La Paz, to man and arm her, and to let me go back to my friends at Mulejé, to cut off their communication with the opposite coast. I hoped also to catch two vessels that were said to be engaged in transporting troops and ammunition. On the evening of our arrival the captain came on board, having Colonel Burton in company; he sent for me and told me he was going to charter the Libertad, man and arm her, and send me back to Mulejé, asking how soon I would be ready. "To-morrow night," I replied. At daylight on the morning of the 9th I took charge of the schooner and began her equipment. Our 9-pounder launch gun was fitted up by a contrivance of mine to work on a pivot; this occupied nearly the whole day, but meanwhile we were getting on board provisions, water and wood. On Sunday morning I went on board with my crew of 11 men, having Midshipman J. R. Hamilton as my officer. I got underway at 10.30, but by the rapid current was swept on a bank from which I did not get off until evening. On the following night I ran into the bay of Descondido for sundry articles I wanted, and sailed again at 3 P. M. of the 12th, passing within sight of Loréto. I forgot to mention that on my previous visit to Loréto, in the Dale, I had been sent on shore to seize some pieces of artillery belonging to the Mexican Government, lest they might fall into the hands of the insurgents. I brought away three small brass guns, an old musket, and some lances.

I also heard here that the force with which we were engaged at Mulejé numbered one hundred and forty men; they had sent down a swaggering account of the fight, such as having routed us and killed six of our men.

Sunday, October 24.—Tossing about in heavy weather in my little brig, with no comfort, little rest, but leading an independent, roving life, which, added to the excitement of my cruise in the Libertad, makes it a very agreeable change from the man-of-war Dale. Since coming up here I have been prying about everywhere, and am becoming quite a terror to the small neighborhoods on the coast. In the early part of the week I made a stretch across the Gulf and looked at the barren cliffs of Mexico, hoping to meet with some adventure. I took a distant view of Guaymas, into which port I wished to run, but thought it my first duty to look again upon Mulejé, as I had been three days absent. So away I ran for its table mountains and broken crags. At daylight on Thursday morning we were off Mulejé, with light, baffling winds, but at sunrise the officer of the watch called me and reported that the wind had come out from the northwest. I ordered him to run for the mouth of the Mulejé creek. By 10 o'clock we were near enough to discover a small sloop at anchor inside; the wind had freshened so much that we had already reefed our sails. I immediately made preparations for sending in an armed party to bring out or burn the sloop. My old pilot told me it was going to blow and that it would not be safe to anchor. I was determined to get the sloop, so anchored, but it was too rough to trust my men to our miserable canoes, and, while busy in contriving an outrigger, I discovered that the sloop had taken the alarm and was warping up the creek. A neck of land covered the hull of the vessel and the men; but hoping to make them desert the vessel and give me thus more time, I commenced firing upon them with our 9-pounder, trying to cut away the spars of the sloop, but without effect. The sea was now running high and the wind increasing to a gale, and I was compelled to turn my thoughts to my own little craft. "You will have to slip, sir," said the old coast pilot, "you can't get that anchor. It's going to blow a gale, and the waters are close under our stern, sir." In fact the old fellow (the quondam skipper of the brig) was very uneasy. But I could not spare the anchor and best chain, and told him we must get the anchor, though in truth I felt very anxious when I found tackles parting and stoppers giving way and the sea

breaking over our bow; but after an hour of hard work we got the chain in short, made sail, and fortunately drove her into deeper water, where we succeeded in getting the anchor up, much to my relief, as I felt that I might need it before the gale was over. I stood out to sea, the little craft behaving very well, but the heavy sea and strong current were too much for her; we could not hold our own, and I was compelled to run off to leeward and make a port. Before night I anchored in a snug bay under the lee of Point San Juan, and there lay three nights and two days in a heavy gale.

Saturday, November 6.—The past week has been full of adventure and excitement. Having made four attempts to get in to the anchorage at Mulejê by night, all of which were unsuccessful because of the calms and light airs off the land which then prevailed, on Saturday, October 30, at 2 A. M., I hove up my anchor. I was lying about six miles from the mouth of the creek, and with a good breeze had a promise of being by 4 o'clock at the desired place, where I expected to cut out the small sloop which we had fired upon last week. But in this I was again to be disappointed; on approaching the creek we had the same calms and light baffling airs as before, and did not get to the place before seven o'clock, at which time all Mulejê was aroused and on the alert.

I now became rather desperate, and finding it impossible to get upon the people by surprise, resolved to carry my plans into execution under their noses. So I landed Mr. Hamilton with eight men to reconnoitre, at the same time anchoring the brig within eighty yards of the beach. A description of the place is necessary to enable one to better understand the localities and the difficulties to be encountered. The village is on both sides of a creek running through a pretty and fertile valley; the waters of the creek are too shoal to admit my vessel, which is therefore compelled to lie outside at a distance of about one mile and a half from the town, for it is that far from the mouth of the creek, and the sloop I wanted to get at was fully two miles from me. Could I have sent on shore twenty men they should have gone in broad day, but as my crew is only thirteen all told, and as I must have some remain to work the gun and take care of the vessel, I resolved to land a party at midnight or towards morning, to bring out or destroy the sloop. Mr. Hamilton and his party having made the necessary observations, came off to the vessel.

No sooner had he left the beach than the Mexicans began to assemble, having kept at a respectful distance while he was on shore.

They offered no violence, however, but one fellow, bolder than the rest, stood on the hill, and throwing up his hat shouted, "Aha, Americanos, muy malditos!" His further cursings were cut short by a musket ball which was sent after him by way of cautioning him to keep quiet.

During the day we were undisturbed at our anchorage. Everything was prepared for a fight, and after dark I hauled the brig in still closer to the shore that I might the better be able to cover the cutting out party. But a watchful Providence, whose guidance I had asked, prevented my sending in the men, for whom I had asked His protection. At about 9 in the evening I discovered that there was a sentry posted close by the vessel. I saw him striking a light for his cigar, and thus was warned that the people were under arms, being alarmed by the Americans lying so close to them. I directed one of my men to fire on the sentry aforesaid so quietly lighting his pipe, by way of letting him know he was discovered. I suppose he was not struck, but knowing that their watch was observed, the Mexicans now passed the call "Alerto," and I could count it from man to man until lost in the distance. We all were under arms, and most of my men lying down, as I resolved, if nothing further turned up, to land my party at all events and try to pass these sentinels. I loaded my double-barreled gun with ball, and threw myself on my bed on deck with my gun by my side, waiting for the small hours of morning, thinking the people would still be surprised by the boldness of the stroke meditated.

I heard no sound ashore, but the passing of the sentry's call, till about half-past ten o'clock, when bang! bang! bang! they commenced from every direction. I jumped out of my bed, seized my gun and fired at the group nearest me, which I could only discern by the flashes of the guns. My men were under arms in a moment, as everything was fortunately prepared. I directed them to fire at the flashes and waste no shot. The pivot gun was soon in operation too, and fired upon such points as seemed to be occupied by the largest groups of the enemy. The moon was rising behind us, so these Mexicans had us as a target against the sky, and kept up a pretty good hail of balls whistling about our heads for about half an hour; but so well did my crew obey my orders to watch and fire only at the flashes (we could in no other way ascertain the position of our assailants, who were constantly changing their stations)—so well, I say, was our fire directed, that in half an hour we drove them from the beach; their fire

slackened, and by half-past twelve all was again quiet. No one on board was hurt, but I decided not to risk my small party by sending on shore that night.

The next morning a boat was reported coming in from seaward. Our canoe was despatched and the brig gotten underway in five minutes, and at noon the prize was brought alongside—a poor, scared beggar, named Juan Battista, who said he was no Mexican, but an innocent sealer, and a native of Italy, that he had been absent from Mulejé three weeks, and had had nothing to do with the war. Hoping to extort from him some information, I ordered his seal skins and goods to be passed on board and his canoe hoisted in. This alarmed him, and I could not suppress feelings of pity for a poor fellow caught thus in sight of his home, where he perhaps had wife and children watching his little boat coming in and witnessing his capture. But I would not let him go, telling him that I regarded him as an enemy, and that I would keep him and give him up to the commandant at La Paz. Finding myself very short of water, I at night kept away to the southward for Lorêto (the nearest good water), and now my prisoner began to wake up; he thought surely enough I was going to La Paz. From him I learned that the forces with whom I was engaged on the 1st numbered about 100, and that none were killed; this last I did not believe. On Monday afternoon my captive could no longer restrain himself. I notified him that if he gave me the information I required I would restore his property and give him his liberty, otherwise he would forfeit both; so before the sun was set on Monday he let me know that he had charge of the sloop owned by Mejia, who got up this revolt. Little by little he gave me all the information I desired respecting her whereabouts; so threatening him with some dire punishment if he were deceiving me, I tacked and stood to the northward, putting the crew on an allowance of three quarts of water per day. On Tuesday evening we again passed Mulejé bay, and keeping on about twenty-five miles, the next morning at sunrise discovered the prize we sought. The townspeople had already taken the alarm and sent a body of horsemen to protect the vessel, I suppose; but I very quickly dispersed them with a few rounds from our pivot gun, and they soon scattered to the hills, while our canoes brought out the prize, a pretty little sloop of twenty tons with everything in fine order. The crew abandoned her and swam ashore as our boats pulled in. Off we went for Mulejé to display the Alerta, for such was the name of the prize, and I have no doubt we were

cursed enough when we made our appearance there on Thursday morning.

My cruise in the Libertad continued until the 19th November without further incident. On that day I arrived and anchored at Guaymas, having received orders to proceed there. On my arrival I found myself just too late for the fight, to explain which I must give a sketch of the proceedings at this place. Late in October the Congress and Portsmouth came to Guaymas, and after delaying twenty-four hours, demanded the surrender of the place, giving five hours for a reply; this was at 1 P. M. No reply was given, and ere the time allowed had expired, night and darkness came on. With the morning light the two ships opened their heavy batteries upon the walls of a deserted town; the troops had withdrawn during the night, carrying the few guns from the fort, and the inhabitants, who were prevented from surrendering through fear of their own troops, had abandoned their homes.

The cannonade was continued for nearly two hours, and the unresisting, unoffending houses suffered considerably. The ships then ceased firing and sent a party on shore to take possession of the empty place, and a proclamation was read. Captain Lavallette made appointments of military commandant, collectors of revenue, and other dignitaries, and sailed, having withdrawn the garrison, and left the sloop Portsmouth anchored off the town. A small rocky islet, about one mile from the town, was chosen as a suitable place for hoisting the American colors; and there they wave, safely removed from danger.

Early in November the Dale arrived to relieve the Portsmouth, expecting to find Guaymas a very respectable place and quite Americanized. The Portsmouth sailed, and the little Dale remained sole monarch of the town and harbor. A new proclamation was to be read to the inhabitants (who had not yet returned, by-the-bye), informing them of the great happiness they would enjoy while under the protection of the American arms, and the pecuniary advantages to be realized by the reduction of duties. Before reading the proclamation, the captain of the Dale, on the 17th November, landed with seventy men; and when approaching the Plaza, was received with a volley from a window, by which he was shot through the foot. Lieutenant Smith (the next in command) then formed the men to fight his way back to the boats. Every house breathed fire from its doors and windows, and the officers thought that the whole party were

doomed to destruction; but the men were so well disposed by Smith (who took up three positions commanding the Plaza), and their fire was so heavily poured in upon the Mexicans, who were sallying from the houses and forming, that the enemy was thrown into the utmost confusion and a flight commenced, about 400 Mexican soldiers being routed by about seventy seamen. Smith and his gallant associates had the satisfaction of seeing themselves left masters of the place. When they were attacked they fought in order to make good their retreat; but so doggedly did they stand and fight more than five times their number, that the foe was panic-stricken. The streets were filled with killed and wounded Mexicans, while of our party none were injured but the captain.

In this affair Lieutenant Tansill commanded the marines, and led that gallant little band into the thickest and hottest part of the fight. Passed-Midshipman Duncan had my company, and all behaved with most admirable coolness and a steady courage which alone turned the scale in their favor.

January 21, 1848.—Since my last date many weary and uninteresting weeks have passed at Guaymas. Toward the end of December the Southampton came in to relieve us for a while, that our ship might go to some place for water; and about the same time I, too, had some little excitement in the capture of a small schooner. I left the ship one day in the launch in search of adventure, and made an excursion to the bay on which the Mexican forces were encamped, about 12 miles from the ship by sea. I pulled in quite close to the beach and threw a few shot ashore among the soldiers, by way of rousing them from their siesta; after which, while coasting along the shores, I discovered a small party, sent out evidently to watch for and get a chance at me, skulking among the bushes. I quickly gave chase and drove them back to their camp. Evening was drawing on and I was on my return to the ship, when, just as the sun was going down, we discovered about three miles from us a schooner running in for the bay. We were about equally distant from the entrance of the creek, and at once a most exciting chase began as to who should reach that point first. We succeeded in cutting her off and I opened fire upon her, as I found they were bent upon running her on shore, and this they succeeded in accomplishing. Night and darkness had come on, but we could not lose our prize, though every moment expecting an attack, as the camp was only about a half mile off. Duncan, who was with me, jumped overboard when we were as

near the beach as we could safely go, and with three men swam to the prize, carrying a tow-line, and we soon carried her out in triumph. She was laden with a valuable and most acceptable cargo of good things in abundance, cheese, figs, raisins, dates, sugar, etc., with all of which we got back to the ship at about 8 P. M.

We left Guaymas December 23, and anchored in the bay of La Paz on Christmas day. A busy week was spent in La Paz, and our ship again made ready for sea ere the New Year was ushered in. At length we sailed for Mazatlan, where we arrived January 6, and remained two days. Mazatlan is the first civilized place we have visited since leaving Lima, and it is a pretty and well built town, with well-filled shops, inviting restaurants, good markets, and beautiful gardens. The town is in possession of our squadron, the Independence and Congress lying here, and having the greater portion of their crews in garrison on shore. Business goes on as usual and everything seems lively and gay.

We sailed on the 8th and ran over to San José where we hoped to meet with the Portsmouth, but to our great disappointment found she had a week before sailed for home. The little town of San José is in possession of the squadron, being garrisoned by a force of 50 seamen and marines in charge of Lieutenant Chas. Heywood. A few weeks before our visit this garrison, at that time only 25 men, was attacked by a body of 150 Californians, who boldly advanced to the assault of the building in which Heywood was posted; but in the onset their leader was killed, and with considerable loss they were repulsed, though a skirmishing fight was kept up for several days. I should not omit speaking of La Paz too, for we found that place nearly reduced to ruins; "grim-visaged war" had visited that pretty village soon after the Dale left. The Californians, in force about 400 men, attacked Colonel Burton's force of 110 New York volunteers posted in two large buildings and the church, and continued a kind of skirmishing siege for about eight or ten days. After losing about sixty of their number the assailants withdrew, but not until they had brought in the brand to assist in desolating the scene. All of that part of the town not protected by the garrison's muskets was burned.

February 1.—Again at Guaymas. We arrived here four or five days since and relieved the Southampton, in which vessel our late commander took passage to Mazatlan. Soon after our arrival we heard that the general in command on shore had sent a company of troops down to garrison the village of Cochori to cut off the supplies

of fresh provisions we had been receiving from that place, and perchance to capture some of our boats; so we made up a "tea party" for the occasion.

On Sunday morn, January 30, I left the ship in command of an expedition to surprise and take this garrison. We went about four miles in our boats, and landing through the surf on the beach some three miles from the village, with quick step and profound silence marched upon the place. On getting near the village I detached the marines, twelve in number, with orders to get near the outpost and lie concealed until I had reached the barracks, that our assault might be made simultaneously. Lieut. Fabius Stanly led the advance, and we pushed on through thicket and hedge until within 100 yards of the barracks undiscovered. We now divided into two parties, Stanly leading to the right, I filing to the left, that we might surround the barracks before assaulting it As my company were filing around the corner of the barracks we were discovered and fired at by the sentry on the house. Stanly had reached the front of the barracks, surprising the sentry there and seizing him with his own hands, not, however, until he had given the alarm. In an instant a number of the guard rushed out from the rear and fired in the faces of my men. I ordered a charge, but as it was pitchy dark some escaped, while others were shot down while flying. As soon as we fired I had the satisfaction of hearing a volley from the marines, who rushed upon the picket guard and overpowered it. Lights were struck and we found we had captured Captain Mendoza and his lieutenant with their mistresses, all in charming *déshabille;* the fair ones, thus by the rude "larums" of war roused from their repose, seemed in nowise agitated, but *au contraire* very interesting indeed. We captured, I say, the captain, lieutenant and eleven privates; in the assault five were killed and two wounded. Twenty stands of arms, 500 rounds of ball cartridges, a stand of colors, and a quantity of provisions also fell into our hands, as well as the guard boat.

Day was now beginning to dawn, and bidding my officer prisoners to put on their clothes, I marshaled my forces and marched them to the beach with all of our spoils, leaving Stanly with a guard to make a more thorough overhaul of the barracks by daylight. I made signal for the boats to come in, and at about 7 A. M. commenced embarking my men. When all were off, I took the officers into my own boat and made my return in triumph to the ship. The captain was very much depressed, but the lieutenant seemed quite delighted

with the idea of not being numbered among the dead. My breakfast was already prepared, and at 10.30 I sat down and entertained my unfortunate guests, giving them stewed oysters, omelette, toast, and hot coffee. So much for the affair of Cochori. The friendly Indians immediately reopened their trade with us and we now get along quite comfortably. A sad business this matter of war! Some hearts were widowed to-day; some were made fatherless. May the God of battles have mercy on those who fell in this their country's cause! Among those killed was a sergeant, in whose cartridge box were found, carefully preserved, several letters from his wife, telling of the health of the children, of her affection, and desire to see him return from the war. She is sixty leagues from here and in a few days will receive the sad news of her loss.

April 3.—For a long time I have written nothing, as there have been no events of importance to note; true, there have been some trifling skirmishes between small parties of our men and the various outposts of the enemy, but nothing serious, and the loneliness of our situation may be imagined when the arrival of a small sloop, navigated by two or three men, would afford us quite an excitement and sufficient food for a day's talk. But to-day our long looked-for commodore arrived, after a journey from home by sea and land of nine months. We are right glad to see him and to receive the letters which arrived, some having unfortunately been lost by the wrecking of the vessel in which the commodore was coming down the bay of Monterey.

The month of April passed away tranquilly. We heard of the armistice and that the war was wellnigh at a close. I most truly wish that it may really be over, for it cannot but be considered an inglorious war for our navy, though brilliant the laurels won by our gallant army. This war has brought to my mind a confirmation of the opinion I have long entertained with regard to the efficiency of the Navy. *Efficiency*, do I say? *Inefficiency* is the term I would use; for most wretchedly inefficient is our Navy, once the pride of our country. How it has fallen within the past thirty years!—during a period when all the civilized world has made such strides in improvement; when the world, blest with a long peace, has turned its attention to arts and sciences, and all the great privileges which can alone be enjoyed in peaceful times, while at the same time the great nations have not been unmindful that peace is preserved only by being prepared for war.

Of all our commanding officers, of whom there have been *five!* on this station during the past two years, Commodore Stockton has been the only one who has come up to my ideas of a naval commander. His conduct has been characterized by promptness, decision, unusual bravery, and boldness of purpose. He has fearlessly discharged the duties of his station without any selfish consideration of personal responsibility, which, alas! is but too frequently the first and only thing by which many of our officers are actuated. From the commencement of the war Commodore Stockton turned his whole attention to the conquest of the Mexicans, and to ensure success in the accomplishment of his purpose, the whole disposable force of the squadron was employed. The squadron, insufficient as it was in numerical strength, was reduced still more so by the negligence of the Equipment Bureau, the men not being half fed and greatly in want of proper clothing. But, notwithstanding all the obstacles he had to contend with and the method of warfare to be adopted by seamen, he figured conspicuously, marching into the heart of the country, declaring his purpose, and with the seamen of the squadron brought the Californias under subjection. You must not suppose me a sworn Stockton man, for I am by no means an admirer of his; he has his weak points, perhaps more than most men, but at the same time he has, by comparison, thrown all of his compeers in the shade, and indeed as an officer I do admire him. He was succeeded by Biddle, who was in his youth a gallant man, and I therefore will pass him over; his infirmities and age* have long since unfitted him for command, and his natural acerbity of disposition causes him to look upon all men with a degree of suspicion. Then came Commodore Shubrick, who after some time applied for leave and was relieved by Commodore T. Ap C. Jones. Who so blind as not to perceive the disastrously disorganizing effects of these frequent changes in the command of a squadron in time of war?

But I will forbear to speak, and pass on to the armistice and its consequences to this place. We, to whom the pleasures have so long been forbidden, may now indulge in a visit to the uninteresting, uninviting town and vicinity. The people, profiting by the temporary cessation of hostilities, are glad to avail themselves of the better shelter of their town houses, and abandoning the huts which had been constructed for their convenience in the neighboring villages, came quickly back to the town, where, protected by our men, they enjoy

* He was 65 years old and died shortly after, October 1848.—Ed.

more liberty of conscience, freedom of action, and security of property than they have ever before known. The shops are re-opened, houses injured by shot repaired, and in a few days the place in everything resumed its former appearance. When I speak of injury done by shot you may think of any number of houses knocked down and imagine all sorts of ruinous injury, but such is not the case. The houses in this country and California, and indeed in most of the towns of Spanish America, are built of adobes, or sun-dried bricks, the walls are commonly about two and a half feet thick, and the greater part of the houses are of but one story in height. These adobe walls when dried by the parching winds of this climate become one mass of brick, one solid brick, so that a cannon shot striking the walls, though it may perchance strike where the corner stone of our houses is placed, merely makes a clean hole and brings down none of the superincumbent wall. The most severe injury inflicted on the people of Guaymas has been by their own countrymen and defenders, by whom the houses have been broken open and pillaged of all movable property and the furniture wantonly destroyed.

One of the first persons I met with on visiting the shore was my old midnight friend—and prisoner—Lieutenant Zaavedra, whom I found installed at the billiard rooms, which are kept by him—a kind of public house, by the way, where liquors of every variety and excellent quality are served up, and where wretched beefsteak and garlic, with a tolerably good omelette, are also served up to the hungry wayfarer. My friend Zaavedra—Don Juan, as we style him—was vastly delighted at seeing me, and, extending to me the hospitalities of Guaymas, in the excess of his pleasure took me to his house. He then entered into a long recapitulation of his sorrows during the war, and I believe he looked upon me as a benefactor, as in capturing him he became released (by parole) from further service; at all events he implied as much, as he unreservedly told me he was very glad indeed to get rid of a service that brought him neither honor nor pay. There was none of the former issued to the Mexicans in this war, and the latter was all appropriated by those highest in rank. He also complained bitterly of the losses he had sustained by the troops, who had not spared his billiard room and its equipments—his liquors they had entirely carried off, from his safely locked store—and the cloth of the tables had been converted into trowsers; however, with a degree of elasticity and good humor quite worthy of a Frenchman, my friend laughed it all off and said his uniform was now for sale.

The people of this part of Mexico are generally of a low class; there is no rascality unknown to the men, and laxity of morals among the females is thought of little consequence, and therefore you find that in three or four families out of five the mother is only a mistress. The women are not pretty by any means, and decay at a very early age. It is not uncommon to see a girl of fourteen a mother; consequently the woman of twenty-five appears ten or twelve years beyond that age. This very early marriage is alike destructive of the constitution and morals. There is but little regard paid to common decency, though they do preserve a semblance of modesty; but their extravagance in dress surpasses all bounds in both sexes. You will see the washerwoman after a day of hard toil turn out on the holiday with a rich silk dress (let me say here that the prices are about treble the cost of such articles in New York) and pearls, with a fine *rebozo*, silk stockings, and embroidered slippers; and you will see a muleteer with a shirt, the only one he possesses, of the finest cambric, its bosom and collar richly embroidered, fine linen drawers, and velvet trowsers decorated with gilded buttons by the gross, and this suit is kept on until it falls to pieces. I have been told that these men pay frequently $30 and $40 for one shirt, and the rest of their suit is in the same proportion of expense. Alas for the pride of the Spanish race, a man decorating himself while starving!

I believe I have not said anything about the bay and town of Guaymas, and may as well devote a part of this page to that purpose. The bay is very capacious and of sufficient depth for vessels of the largest class, though the water is shoal near the town. When in the bay the view is on every side bounded by rugged and barren hills, on whose sides there is not a solitary spot of green, though there is a sickly little bush with very minute leaves, and the cactus grows to a giant size in the parched and thirsty soil. I have seen its stalks shooting up twenty feet and more, and nearly two feet in diameter. Some of its varieties bear a rather agreeable fruit, which in the autumn constitutes a large portion of the food of the poorer classes. There is no agreeable vegetation, no groves of trees upon which the eye may rest—all is barrenness. The town consists of but three streets, running parallel with the shores, and its population is about twenty-five hundred. The houses are of adobes, one lofty story in height; a style of building admirably adapted to the country, for the very thick walls most effectually exclude the heat, which is here intense. The roofs are covered to a depth of eighteen inches with

clay; these, with the brick floors, make the houses very comfortable. At night the people sleep in the open air; those who have a court-yard within their walls spread their mats there, and those who have no such place of privacy spread theirs before the doors in the streets, men and women, in very primitive style. In the immediate rear of the town the hills rise nearly perpendicularly to the height of nearly two thousand feet, and seem, with their "horrid crags," to overhang and threaten the place.

The captain, purser and myself made a party for an excursion to San José, or Rancho, as it is most commonly called. An American gentleman of the place provided us with a carriage, two mules and muleteer; he too accompanied us, and off we started on one of the hottest days of June. Our road ran through a valley perfectly level the whole way, but all was barren and burnt up, and I am told that such is the character of the country throughout its whole extent for hundreds of miles. At the Rancho, which is merely a small village of adobes, we were very civilly received by the authorities and some of the "upper ten thousand" whom we visited, and in the cool of the day returned again to Guaymas, without having seen or learned anything worthy of remembrance.

Soon after the armistice we were visited by a portion of the Maricopas, a tribe of Indians from the river Gila. They came, so said their chief, to see the Americans of the United States, hearing that their country was to be taken possession of by them; they came to let us know that they were always our friends and were glad to come under our rule. They were nearly naked; the most conspicuous article of dress was that worn by their chief, in the way of a nose ring. A huge silver ring with a plate nearly as large as a quarter of a dollar was stuck in his nose, and being an ornament designating rank and high birth, he seemed quite possessed with a sense of his own importance; but, without jesting, this rude son of the forest had more of the natural dignity of rank than you commonly find among the better dressed civilized races. He spoke Spanish tolerably well, and seemed full of life and spirits. The style of dressing their huge shocks of hair being peculiar I will mention it, as it may some time be adopted by our fashionables. The women had their hair thickly plastered with mud; whether to keep their heads cool or to destroy vermin I know not, but they appeared to think it very fine. Our captain invited them to visit the ship, and they accepted the offer with so much avidity we supposed them different from the Indian

race, thinking they were moved by curiosity. But not so; the usual apathy of the red man was never more conspicuous; they expressed no astonishment whatever, though they had never before seen a vessel of any kind. We asked them if they had ever heard a large gun fired? "No." Well, a large gun was cleared away, and being directed over a range of waters, fired. Still there was no astonishment other than was expressed in the "ugh"; but about a mile and a half from the ship the shot struck the water and commenced skipping along, then indeed they forgot themselves and gave a shout of admiration and wonder. That a ball nearly as large as a man's head should be thrown such a distance was beyond their comprehension, and at every graze, as a volume of water was sent up high into the air, there was a fresh shout. This was the only thing that pleased the Indian.

In June a vessel arrived bringing letters; and in June, too, we suffered from the scorching north winds. How hot they are! how insufferable! No hot blast from a furnace can be more parching; the air, at all times excessively dry here, is beyond endurance when the north wind of summer comes rushing along over these sun-burnt hills of Sonora. In the latter part of this month of June more letters were received, and I got several that came overland, one of them but seven weeks from home.

In the last week of June the Ohio and Congress arrived at Guaymas, causing quite a sensation, enlivening not only us, for the whole country for miles around seemed to be aroused by such an event. No ship-of-the-line had ever before visited Guaymas; so not only did the people of this place crowd on board, but many families came from a distance of one hundred and fifty miles to see the Ohio, and all were delighted with the magnificent ship. Her coming was the occasion of considerable festivity, too; dinners and dances were quite the order of the day. We had just received news that peace was concluded, and this was additional cause for rejoicing.

July 1.—The Dale evacuated Guaymas, hauling down our national colors under a salute of twenty-one guns.

July 4.—The day was celebrated on board the Ohio in a manner not soon to be forgotten, I presume, by those concerned. The Commodore gave a collation at 1 P. M., and in the evening a *tertulia* was given on board our ship, when the beauty of Guaymas assembled, if it may be called beauty. However, there were two or three very good-looking women from the interior; they danced and waltzed

gracefully, and with the fine band from the Ohio we made a very pleasant night of it. An Indian ballet was danced by a bride; the dance was unmeaning and ungraceful, and the music a few simple notes, but the woman was pretty, and the chief charm of the dance was in the timbals worn on the knees and with which she beat time to the music.

July 5.—On this day we took our departure from the detested bay of Guaymas, and in company with the Ohio and Congress sailed for La Paz, where we arrived on the fourth day out. Lower California for some unaccountable reason has been given back to Mexico, and consequently there is great distress among those of the inhabitants who, during the war, have compromised themselves by their adherence to the Americans. It must not be forgotten that, by the proclamation of our naval and military commanders, *the whole* of California was declared to be annexed to the United States; this was done not only by authority, but, under instructions from the Government, protection was promised to the inhabitants, and their property and rights guaranteed to them. A force was also sent to occupy and garrison some of the principal ports, and things thus went on quietly for a few months; but the spirit of insurrection, which had been crushed in Upper California, was by some designing men revived here, where they hoped by an overwhelming force to reconquer the territory and thus make themselves "buen merito" of their country. When the insurgents took up arms other proclamations were issued, enjoining all peaceably disposed people to remain at their houses, protection was again guaranteed to those friendly to the Americans, and there being quite a party so disposed, they naturally availed themselves of the assurances held out, espoused the cause of the United States, to which they wished to be annexed. But after all of these proclamations and promises these unfortunate people have been betrayed, their territory passes back to Mexican domination, and many of them are threatened, not only with the confiscation of property, but with death. So we find our old friends of La Paz in great trouble, for all of the best portion of the inhabitants had taken up arms in support of our flag.

After a delay of three or four days only at La Paz, our ship, being of convenient size for despatch, was sent over to Mazatlan for mails. The country about Mazatlan, watered by the showers that are now so frequently falling in these latitudes, is quite green, and it is really refreshing to see a landscape with its green hills and fruitful vales,

and then, too, to get some of the fruit. After our long banishment to such out-of-the-way places as Guaymas, Mazatlan seemed quite like a city; and indeed it was high time for us to get to a place where our many little wants could be gratified, and I had quite a busy day on shore shopping. It was so long since I had been into a respectable store, I could not help going about and looking at the many pretty things to be seen here.

We found the Mexicans in the midst of a fresh insurrection. No sooner is their war with us over than they recommence their own fights; the whole country is in a state of disorganization, and I don't know when the wretched people will have any quiet and orderly government. They are certainly not at all qualified for self-government, being too ignorant and too easily deceived by their military leaders, who are their rulers. The various chieftains are always struggling for their own aggrandizement, and there can be no quiet, no law, no security in Mexico while such things exist as are at present permitted.

After four days spent at Mazatlan we again sailed for La Paz, where we arrived on the 27th of July, and are quite pleased again to be in a snug harbor where we can have such luxuries as milk in our coffee, and fine figs and grapes.

Sunday, August 27.—The weather is very hot to-day, and we are bound in for Mazatlan, where I hope to find letters from home. I believe I have elsewhere made mention of the fact of my reading prayers on Sunday to the ship's crew; I have been in the habit of doing so for several months past by the captain's request, and I have used the prayers of the morning service. This morning I read the Litany—that most solemn and beautiful portion of the Liturgy.

September 26.—The month of September has nearly gone and will soon be recorded in the past. It is some weeks since I have written anything, though agreeable events have taken place—most agreeable changes in our cruise, brought about, as it were, accidentally. On our return from Mazatlan to La Paz, where we arrived on the 7th of this month, we found none of the squadron; all had left, and the troops which were to have gone up by land had also gone away in the ships. This was to us a most unexpected event, and as matters have turned out we are delighted. The commodore probably expected to meet us at sea, for he left no instructions whatever, whether we should follow, or carry out the designs which he had verbally communicated to our captain; therefore it was at once resolved to water ship, go to Mazatlan, and if no orders were received, to pro-

ceed to the Cape, with the expectation of finding there some news for our guidance. While we were lying at La Paz we had, on the 25th, a furious hurricane which was, fortunately, of short duration, for in its violence it destroyed nearly one half the town. Our ship having been made snug did not suffer, but from this rough specimen we are able to form a pretty correct idea of the autumnal gales of this quarter of the world

We sailed from La Paz on the 14th, touched at Mazatlan on the 18th, and in the evening we filled away for Cape St. Lucas. Before reaching that place, however, a change came over the spirit of our captain's dreams, for on the 21st, the cape in sight, the weather assumed a most threatening aspect, and all things seeming to portend a gale such as we had experienced at La Paz, the wind beginning to blow right wildly from the southeast (the worst quarter here), it was at last decided by him that the most proper course to pursue was to follow the commodore. This was the point we had been trying to attain, and right glad was I when in my watch the order was received to "keep away." A solid year spent in the Gulf of California was thus put an end to, and our fears that we should still be detained two months longer were thus extinguished, so on the 21st of September we bade adieu, I hope a long adieu, to Lower California. But the sea of Cortez did not seem disposed to relinquish its claims so easily; for three days we were buffeted and tossed about in its parting gales; a most unusual wind from the southwest coming in and seeming to dispute our exit; but good weather has come again, and we now look for our arrival at Monterey to see what will turn up next.

November 11.—*Monterey. U. S. S. Warren.* Yes; I have with a vengeance seen what was next to turn up. We arrived at Monterey on the 15th October and found the Ohio at anchor, a few days ahead of us only. On the 19th the commodore sent on board of the Dale a special order in relation to the discipline of the squadron, by one part of which watch officers were not to be allowed to go on shore. I may here observe that the temptation held forth by the easily procured gold at the "placers" was irresistible and the desertions from the Ohio were without limit.* In a moment of vexation the above capricious order was issued; it is sufficiently evident that such an order was by no means calculated to prevent desertion, for the opportunities to desert were not at all lessened, as the intercourse with the shore was the same as before, the boats constantly plying at

* The Dale did not lose a man by desertion while on the station.—Ed.

their usual hours with "idlers" (those who do not keep watch) on liberty.

The injustice of the order was so apparent, and it was so directly at variance with usage and law, that I, for one, could not but look upon it as an outrage; so I sat down at once and addressed a letter to the commodore requesting him to reconsider his order, that it might be withdrawn or made *general* in its operation. Many others felt as I did but did not care to run against the pricks; two lieutenants of the Ohio did make verbal remonstrance. The day after my communication was forwarded a confidential communication was addressed to us three complainants, which document was so carefully worded, and its special pleadings so artfully woven, that it was evidently intended as a net behind which the commodore should partially screen himself and in which he might catch the unwary. I thought it unsafe, therefore, to enter into a correspondence on the subject, being determined to "bide my time" and make my complaints at home.

A day or two after the confidential address appeared the restriction was removed, or rather deprived of its obnoxious points, though the liberty was not so great as was desirable, yet none could complain. I was at this time sitting as a member of a court-martial, which adjourned on the 31st of October. On the evening of that day I received, through Commander John Rudd,* an indirect and confidential bit of advice, to wit, that I had better recall my letter or explain it away. I immediately replied I would do neither; that as for withdrawing it, I saw no necessity for so doing; it was true the restrictions had been removed, but I had written it previously to their removal, at a time when I considered myself aggrieved, and as for explaining, or in other words, apologizing or saying I did not mean what I said, I would not be guilty of such a folly. I meant all I said and would submit the matter to any tribunal. I would never withdraw what I had said. The conversation on the matter was ended by Rudd's saying, "I give you this advice as a friend, lest any trouble or future difficulty should grow out of that letter." I thanked him for his kindly feelings and assured him I had acted from a sense of duty; that as for any trouble or difficulty, I apprehended none; there was nothing in my letter which could be considered exceptionable, and although I would not wish to be brought before a court on any pretext, I did wish to see matters of this kind tested, and I should

* Commanding the Dale.—Ed.

stand upon my rights. The Dale was to sail on the following day on a short cruise, after which she was to go home. The Dale was, however, delayed until the next morning after, but while eating my dinner (Nov. 1) a peremptory order was brought transferring me to the Warren. Somehow or other I had had a presentiment of some such thing, and therefore my mind was in a degree prepared for it.

I left the good ship Dale on the morning of 2d November. I felt like leaving a home; many of the men wanted to go with me and share my fate whatever it might be. I considered this as the most flattering evidence of the good will of sailors; but even this proof of their regard and respect did not prepare me for what took place. As I shoved off from the ship, the crew, seeing me leaving, had with one consent gathered on the forecastle, and as I left they gave me three such hearty cheers as would gratify any public man who sought popularity. The feelings which were aroused within me were those of gratification indeed and surprise, for I had not sought popularity, and had only tried to do my duty. I knew indeed that the crew had confidence in me as an officer, but I knew not that their good will was so general. I almost shed a tear at this honest token of Jack's affection; and I felt, too, that the commodore had unwittingly made me an object of honor.

On board of the Warren I find myself quite contented and comfortable. The old ship is pretty much of a wreck, but we have a very agreeable mess, and I am resolved to be contented.

January 28, 1849.—I have in general committed to my pages here only such matters as may be agreeable and instructive; this last word seems out of place, as who should find instruction in anything relating to California customs and the usages of California society? But say what they may who have croaked over this country, ridicule has now turned to wonder, and the croakers, the scoffers, the *loafers* are all crowding to California. Such is the power of gold over the minds of men, that places hitherto looked upon as uninhabitable, dreary tracts of waste avoided by the beasts of the field, mountains with their cragged sides and tumbling torrents, are now the goal for which all rush with an eagerness more deplorable than can be imagined. Covetousness, with its attendant vices, never had so fair a field of action since the world began; gold is the first thought of the dawning day, the last thought of the twinkling twilight, and aye the glittering metal still hangs about us in our dreams, gilding all we touch, and many the bright, airy fabric raised in our fancies during slumber.

But slumber and the dead hours of night are favorable, too, for the designs of those upon whom the dread sin has wrought, or developed the vice in its most terrible shapes. Murder and robbery stalk about in the midnight darkness, and amid the cries of the coyote may oft be heard the screams and cries of the victim who for his gold is sacrificed.

On the night of November 14 a number of men belonging to this ship, having gained the faithless sentry, lowered a boat which had been hoisted under the bow for painting and repairs. The officer of the deck heard some noise and his quick ear detected some foul play, so seizing a musket and calling to the corporal of the guard, he ran forward in order to stop a portion of the crowd who were rushing for the boat; for the movement was evidently well arranged and had many participants. Six men had already leaped into the boat, and among them the sentry by whose baseness the plot was permitted. Finding themselves discovered the mutineers pushed off; the officer ordered them back or he would fire into them. "Fire and be damned!" was the reply, with a threat also of firing back, for the sentry had carried his musket. The officer fired and ordered the corporal to do so. Three shots were quickly fired into the boat, though it was too dark to distinguish anything save the one object on the water moving rapidly away. Meanwhile a boat was lowered and an exciting chase commenced; the distance to the beach was short, and the pursuing boat reached there a few moments after the pursued. The deserters had all escaped save one, and that one the treacherous sentry; one musket ball had singled him as its victim, and he lay groaning in the boat with a ghastly wound. His leg from the hip to the knee was laid open to the bone, the ball having then passed through the leg below the knee, shattering the bone. Thus was he, who but a half hour before paced on his post in the full vigor of manhood and health, now brought back to the ship a criminal, dreadfully wounded and crippled for life, a life of suffering and disgrace. That musket ball was well directed, and conveys a moral to every one placed in a situation of trust, to every one whose sworn duty it is to guard and protect his country's hônor and interests.

But let us follow those who succeeded in effecting their escape. Three seamen, Wm. Banbury, Peter Reamer, and Peter Quinn, with two marines, safely reached the shore; one, as we afterwards learned, had a bullet through his cap. These five miscreants are bound to the gold regions, and already fancy themselves among the successful

miners; visions of wealth are already dancing before them, and they hurry on, rejoicing in the brighter days in anticipation. Do they know they have three hundred miles to travel? Do they know that their journey is over mountain path and desert wastes? Do they know that the settlements are but remotely situated on their road, and that no friendly hand will give them bread or meat or shelter? Food is too dear; flour is at one dollar per pound where the gold is plenty, and as for shelter, men do not now trust strangers willingly; too many deeds of violence are committed, and those who have houses like not to entertain unknown travellers, on foot, too, and without money. But on they journey; they must not tarry, for they are pursued, and they must be quick and wary or they will be caught; so they diverge a little from the road, and after a walk of some fifty miles reach a place called Soledad. Here they meet two other fugitives flying from the very region to which they are hastening, two scoundrels named "Mike" and "Lynch," who a few days before, having begged shelter and food at the camp of two miners, had during the night most brutally murdered their hospitable entertainers and robbed them of their gold. The alarm is given, the avenger is following, and on horses stolen they fly for life. At Soledad they meet the five deserters, a choice gang are they, and the hand of fellowship is crossed.

The marines, however, fortunately for themselves, seemed to have tired of their partners and at this place dissolved company. The murderers represented to the seamen that mining was at this wintry season impracticable, and proposed striking to the south, where more genial climes were found, and wine and women with their sunny smile all invited to the south for the winter. "We have," said they, "money in plenty and will share with you; at the first rancho, too, we will buy you horses." The willing sailors not needing much persuasion, joined the two whose hands were already dyed in blood, and the five set out for the south. At the first rancho they stole three horses, and thus all are mounted, though the sailors are but badly off for equipments. In a day or two they reach the friendly roof of an Irishman named Read, who with his native family occupied the deserted missionary establishment of San Miguel. This man invites them in and good substantial food is placed before them, a cheering fire blazes on the hearth, and there they rest their wearied limbs, passing the evening in tales of wondrous import, the fanciful mind of the Irishman exaggerating the great wealth of the miners and vainly boasting of his own successful expedition to the region of gold, for he had

but recently returned, and he showed his store of treasure to the covetous crew around him. Ah! little did he suspect that blood was on their hands, that Satan was again busily at work among them. With that vanity which generally leads man into a display of his wealth he exhibited his gold, the goods, too, he had bought for the winter's supply and comfort of his family; he was always poor before, but now may sit down and while away his time until the gold harvest again commences, quite at his ease. Here are silks and fine things for those who were poorly clad before, here is an abundance of food for those who were but lately half fed, and see, he has still a large store of treasure left.

"But come," he says, "sit down, boys, bring more wood and let us be comfortable." The two murderers brought out some of their ill-gotten gold, too, and their host bought it of them, paying down the cash. At length they yield to fatigue and rest in sleep. In the morning they partake of the comfortable breakfast which their host spreads before them, and for which, and for all his kindness, he will accept no compensation. They leave him at ten in the morning, but proceed a short way only on their journey when they halt. "It is a shame," says Banbury, "to let this chance slip by, we ought to have that money." He perhaps was only giving utterance to thoughts busily at work in the hearts of all, for with but few words they all turned back. "Boys," said Read, as they approached his door, "so you have all come back; that's right, come in and be comfortable, 'tis of no use to travel in such bad weather." "Yes," they replied, "our horses are jaded and we are pretty well worn out, and we are so very comfortable by your fire we have concluded to stay another day and rest ourselves." Evening came on and they busied themselves in cutting wood and assisting in the work of making each other comfortable for the night—cold-blooded villains, thus to be, as it were, gloating over their victims; but darkness alone will suit their works—they would recoil from such deeds in daylight, so they wait for night. Too soon it comes and throws its mantle over the scene, but by the red glare of the cheerful fire they sit and smoke their pipes and talk and laugh, while all the time hell is raging in their minds. Soon a dull leaden sound is heard—a blow, a groan, and the old man falls—Banbury has struck him on the head with the axe, twice or thrice the blow is repeated, and though life must be extinct, another of the murderous gang stabs him with a knife. An old Indian servant is sleeping on the floor; the axe soon sends him to

his final rest. "Come on," says Banbury, "there's more work to be done," and he opens the door of the bedroom where the mother and her children and the rest of the family are sleeping, but the noise has disturbed and alarmed them. "Buenas noches, señora," was the salutation of these villains as they entered the room, and now commenced again a most awful scene of butchery—all, all were slaughtered. I find my very thoughts stand still in attempting the recital, so awfully heartrending must have been the scene in that room. Mother and children—vainly do they beg for mercy where there is none; tears and shrieks and prayers that might have moved a heart of stone are all lost here where hell-hounds are at work and gold is the object.

One little fellow has crept under the bed—poor boy, better had he waited and suffered a more speedy death; he is shot at once or twice, and then dragged out to have his skull cleft. There is still one left, a little child, an infant, unconscious of what is going on. The wretch Banbury brought it out of the room saying, "I have not the heart to kill this child." What mockery! Another fiend at his elbow took the smiling baby, and going back to the room, soon returned, saying, "I quickly finished *that one*." And now they rifled the house of money and goods till all are laden with more than they can carry, for this plunder being dropped along their road served to trace them up. They are rich now, and after travelling a few miles buy fresh horses, for they must hasten out of that section of country. They met the dragoon mail-rider coming from Los Angeles to Monterey; he passed them, and in a few hours stopped at the scene of butchery. The stout heart of the soldier must have quailed, but no time was to be lost. He hastened to the nearest settlement, gave the alarm, and then resumed his journey, spreading the report through the country lying along his route with all the speed his horse could give him. He well described the five men whom he had met as being of a suspicious appearance and coming from the direction of the murdered family.

But let us return to the gang of cruel devils who thus in human form are travelling onward. Treason is at work among them, and surely vengence is at hand, for the country is aroused through an extent of a hundred miles or more. An Indian boy had attached himself to this gang and followed them from Soledad; he too had assisted in the murders. The day after they left the house of Read, guilty men as they are, each begins to suspect the other of treachery; but first their minds fall upon the Indian boy. A foul-looking fellow is

he, with his dusky skin and shock of wiry hair, with his filthy blanket hardly covering his naked legs; but he has keenness in his eye and soon detects the suspicious glances thrown towards him. "That boy must die," said one. "Not here," muttered another; but the boy reads their minds, and snake-like he crept away from their camp-fire that night, and was not missed by the watch till he was beyond their reach. He is a cunning fellow and takes the very road from which pursuit may be expected. He meets the pursuers. "Have you seen five men, boy, and what road are they on?" "Yes, I have come on the Santa Barbara road and met five men, Americans, on horseback." The gang pass by Santa Barbara and camped for the night a mile or so outside the town. No wonder they avoid the dwellings of human beings, for they are but beasts of the mountain, tigers of the most cruel kind. They rested that night and made merry on some liquor bought on the road. At early day they started again; but here comes the avenger!

They were hardly in the saddle and on their road ere they are assailed from every point by mounted men, who challenge and call on them to "halt." A shot of defiance was their reply, for they know the desperate situation in which they are placed, and now commences their turn for being put to death. Banbury and "Mike" fell in the melée; the former, having killed one of his assailants, leaped from a cliff into the sea, but he was wounded and the gold weighs him down; he cannot swim, and vainly he tries to reach the shore again, crying out for quarter. He sunk, and the cold wave closed over this icy-hearted villain whose moans were heard only in the sea-bird's cave.

Lynch, Reamer, and Quinn were captured and secured. The fury of the crowd which surrounded them was with difficulty restrained; a brave and gallant citizen had fallen in the pursuit. Don Ramon Rodriguez with his lasso had fearlessly dashed after one of these miscreants, lassoed and dragged him from his horse; the man in falling shot him, and the wretch Banbury also fired another shot; Rodriguez fell, but ere he died saw the whole party killed or captured.

The prisoners were judiciously placed in different rooms and safely guarded. A few days after their capture, the people of the town being ignorant how to proceed, were glad to see an officer and two dragoons ride in. A lieutenant had gone from Monterey in pursuit; he had taken the road for Los Angeles, and passed by Santa Barbara ere he heard of the affair there, so he hastily retraced his steps,

and on getting to that place, advised the good citizens how they should proceed to trial; for there is at this moment no regular administration of law in this territory, martial law having ceased and the civil not being established. It was well for the ends of justice that Lieutenant Ord arrived at this opportune moment, for the murderers had a chance of escape. In the first burst of passion on capturing the villains the populace were for wreaking upon them instant and dire vengeance without the formalities of trial; they wished at once to avenge the deaths of their friends, and it was with great difficulty they were restrained by those who desired rather to proceed calmly and according to the usages of law and good order. The prisoners were placed in close confinement, the tumult subsided, and the excitement being over, the people were at a loss how to proceed, for they were without organized courts, and in fact without any immediate right to place the criminals on trial. In this dilemma they began to relax somewhat in their vigilance, and at the time the officer arrived there was no watch kept on the prisoners. Lieutenant Ord called their attention to the matter and ordered that a hired guard should be kept at the prison house, and also gave the necessary advice and instructions with regard to the trial.

The three murderers were placed on trial, found guilty, condemned and executed within three brief days, and it was not a little remarkable that each one on trial stoutly denied his own guilt, but bore witness against the others; each one was an unwilling witness only in the terrible slaughter, each exclaimed against the butchery but was forced by the others to remain—this was the substance of the defense of all these villains; and there was some reason to suppose that in the case of Quinn there was a shadow of doubt as to his having entered willingly into the diabolical plot, but his hands did assist in the butchery, and his case is a striking illustration of the dangerous effects of bad company—it brought him to a felon's end.

March 14, 1849.—Let this day be long remembered as one of the bright days of my life—a day made bright and cheerful and happy by thoughts of home. I am now going home. We sailed for home at daybreak on the morning of this day, and though the winds be light we are on our way.

On the 16th February I sailed from Monterey in the Warren, and arrived at San Francisco on the fourth day after. The commodore was absent in the Southampton up the bay and did not return until the 23d February, after an absence of three weeks. Three or four

days after his return I was advised by Capt. Rudd to apply for the Dale in person. I had resolved that I would never make application to Commodore Jones, but for reasons which satisfied me I was induced by my friends to change my mind. I therefore called upon him one morning, and he without hesitation said he would order me back to the Dale. My friend Rudd had previously applied for me, but no satisfactory answer could be obtained. In the course of conversation with him he said, "Mr. Craven, I wanted to have a talk with you about a letter you wrote to me in Monterey and which I did not like." I replied, "Commodore, in writing that letter I did precisely as you would have done under the same circumstances." "Be that as it may—I don't know; but when I ordered you to the Warren I intended to bring you to a court-martial," said he; "but I advised with Capt. Stribling, and am perfectly satisfied that you intended no disrespect to me." I replied that I had at the time told Capt. Rudd that I had no intention of treating the commodore with disrespect, but considering my rights invaded, had under that feeling written the letter.

On the morning of our sailing I received from Commodore Jones messages by the captain and purser complimenting me on my survey at Monterey and saying he had intended writing me a letter on the subject, but his business had so completely occupied his time as to have prevented his doing so.

Valparaiso, May 25.—We arrived at Valparaiso on the 8th of May after a pleasant though tedious voyage of fifty-five days. We have been detained here three weeks waiting for Mr. Breton, our chargé d'affaires, who is going home with us. It seems that this worthy old personage has become enamored of a Chilian maid and has married her. The marriage ceremony was performed by the Presbyterian chaplain of the Independence, and in consequence of not having conformed with the forms of the Roman Catholic Church they have brought upon themselves the displeasure of the bishops and priests, who consider themselves outraged in the matter. Excommunication and a thousand other evils have been threatened the lady, and in her anxieties on the important subject old B. has fired up and quarreled with the whole community, Church, State and all. He in his turn has threatened a bloody and exterminating war, promising that the archbishop should be seized, taken to the United States and tried by court-martial; in other words, the old fellow has been making himself the laughing stock of society here. On the 20th of May they

arrived in Valparaiso; this loving pair, accompanied by her sister and maid, all to take passage to the land of freedom. Neither of them can speak the language of the other.

We were completely overwhelmed by the crowd of American emigrants here on their way to California, that "land of promise"; vessels coming in every day filled with passengers, who crowded about us when we were on shore, and who constantly visit us on board to inquire about the land where gold is plenty; wishing to see and touch those who had come from El Dorado, and be assured that their dreams of riches were not too highly gilded. Thousands are going to California, thousands must there meet with disappointment and despair, and thousands will never return to the happy land they have left.

May 30.—On the night of the 26th we sailed from Valparaiso for stormy Cape Horn, and at this moment our gallant little ship is most nobly speeding on her way towards the icy regions.

July 28.—To-day we are in 6° north latitude in the North Atlantic! Last night the north star was visible with its twinkling light, giving promise of our distant homes. To-day small quantities of "gulf weed" have been seen, and I really feel that we are drawing near to our own shores. God grant us a speedy and happy arrival, a happy reunion to our friends.

Sunday, August 19.—Last Sunday we had great hope that we should on this day or to-morrow arrive at New York, but have been disappointed in having light winds and calms; to-day, again our prospect is improving. We are now as I write some three hundred miles from home. Just think of the feelings one enjoys in the thought, one who has been so many thousands of miles distant, and so very, very long absent—it is difficult to realize. How many will be made happy by the arrival of our ship, how many hearts will beat with love and rejoicing! and, I regret to say it, to some we will bring most agonizing intelligence. Some who are daily and anxiously looking out for us, cheered by the hope of being speedily reunited to the absent ones, will only hear of our arrival to learn that man proposes but God disposes. In the neighborhood of Cape Horn our sergeant of marines died, a married man, leaving a wife in Poughkeepsie; his illness was of some weeks, the revival of an old chronic dysentery.

And now again, when so near home, our ship has been overcast with gloom by a very sudden death among us—Midshipman W. B. Hayes, a young gentleman of very bright promise, great intelligence,

and one of the most correct youths I have ever seen. He was taken ill with a violent fever which, though somewhat alarming, did not seem attended with danger. On the tenth day, however, he was pronounced by the doctor as convalescing, but all were deceived; his constitution was too delicate, the fever had done its work and left him nearly exhausted, and on the twelfth day, much better in the morning and in fine spirits, he was taken at noon with hemorrhage of the bowels and died before night, August 10. What a sad blow to his family, of whom, I am told, he was the idol. I have often thought how great would be the happiness of his mother and the many who so loved him on seeing him return—a man, who had not forgotten *one* of the good precepts taught him in youth. He was most deservedly a favorite with every person; officers and men were alike fond of Hayes; but the unerring shaft has singled him out from among us, and God grant that our minds may be thus brought to a more close consideration of the uncertainty of life, the vanity of all earthly pleasures.

I thank my God that health and life have been continued to me, and pray that my heart may increase in fervent devotion to Him who is the giver of all good things.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A NEW METHOD OF REDUCING CHRONOMETRICAL LONGITUDES.

By Ensign A. B. Clements, U. S. N.

Observations for the determination of the longitude of the mouth of the Keum river, Korea, were made by the officers of the U. S. S. Alert, in June, July, and August, 1884. The Alert being at that time a regular cruising vessel of the Asiatic Station, her other duties prevented her making more that one round trip from Nagasaki, the origin of longitudes, and from remaining there long enough to rate chronometers either before or after visiting the undetermined points. The sights obtained were as follows: At Nagasaki, June 14.5, equal altitudes for error; at Chemulpo, June 27 and July 8, equal altitudes for error and rate; at Keum River, July 23 and August 3, equal altitudes for error and rate; at Nagasaki, August 13.5, equal altitudes for error.

The Alert carried five chronometers, 1349, 1636 and 1458 Negus, 372 Hutton, and 2171 Poole. On working up the longitudes of Chemulpo and Keum River by the methods and formulæ published by the Department and given in the books of reference, a great divergence in results by the different chronometers was found and a better method shown to be necessary. While investigating this subject I was, by the courtesy of Professor Wm. Harkness, U. S. N., allowed to examine his manuscript, dated August 28, 1886, yet unpublished, of the reduction of chronometrical longitudes in connection with the Transit of Venus expeditions. This, I believe, was a new application of the method of least squares to chronometer rates in the determination of longitudes, and led me to examine into the applicability of least squares to the general problem of the reduction of chronometrical longitudes. I was soon satisfied it could be used

with great advantage and offered a satisfactory and general solution, adaptable to any circumstances that might arise in cruising, and utilizing to the best advantage any data that might be obtained, however meagre.

The following is the solution of the general problem, with the special case of the Alert at Chemulpo and Keum River as an example.

Suppose a vessel starting from a position A whose longitude is known, touches at several places X, Y, Z, etc., whose longitudes are unknown, and finally at B whose longitude is known; that sights for error of chronometer on local mean time are taken at each place and that at some of them sights for rate also, and that the longitudes of X, Y, Z, etc., are wanted.

We will assume the notation of the following table:

Name of Station.	Longitude.	Correction to Local Mean Time.	Interval between Sights.	Rate.
A	L_a	C_a		
			Δ_a	r_a
A	L_a	C_a'		
			Δ_{ax}	$R_{ax}+v_1$
X	L_x	C_x		
			Δ_x	r
X	L_x	C_x'		
			Δ_{xy}	$R_{xy}+v_2$
Y	L_y	C_y		
			Δ_y	r_y
Y	L_y	C_y'		
			Δ_{yz}	$R_{yz}+v_3$
Z	L_z	C_z		
			Δ_z	r_z
Z	L_z	C_z'		
			Δ_{zb}	$R_{zb}+v_4$
B	L_b	C_b		
			Δ_b	r_b
B	L_b	C_b'		

R_{ax}, R_{xy}, R_{yz} and R_{zb} are assumed from such known rates r_a, r_x, r_y, r_z and r_b as have been determined corrected for temperature, etc., and v_1, v_2, v_3 and v_4 are unknown corrections to reduce the assumed rates to most probable ones.

Each trip will give an observation equation as follows:

A to X, $\quad C_a' + \Delta_{ax}(R_{ax}+v_1) + L_a - L_x - C_x = 0.$ (1)

X to Y, $\quad C_x' + \Delta_{xy}(R_{xy}+v_2) + L_x - L_y - C_y = 0.$ (2)

Y to Z, $\quad C_y' + \Delta_{yz}(R_{yz}+v_3) + L_y - L_z - C_z = 0.$ (3)

Z to B, $\quad C_z' + \Delta_{zb}(R_{zb}+v_4) + L_z - L_b - C_b = 0.$ (4)

Adding and putting

$$W = C'_a + C'_x + C'_y + C'_z + \Delta_{ax} R_{ax} + \Delta_{xy} R_{xy} \\ + \Delta_{yz} R_{yz} + \Delta_{zb} R_{zb} + L_a - L_b - C_x - C_y - C_z - C_b$$

the known quantities, we have

$$W + \Delta_{ax} v_1 + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4 = 0. \qquad (5)$$

This is the only equation of condition and must be satisfied exactly.

From the theory of least squares,

$$v_1^2 + v_2^2 + v_3^2 + v_4^2 = \text{a minimum}. \qquad (6)$$

Substituting the value of v_1 from (5) in (6),

$$\left(\frac{W + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4}{\Delta_{ax}} \right)^2 + v_2^2 + v_3^2 + v_4^2 = \text{a minimum}. \qquad (7)$$

Differentiating (7) with respect to v_2, v_3 and v_4 separately and equating to zero to find minimum values,

$$\frac{2(W + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4)\Delta_{xy}}{\Delta_{ax}^2} + 2v_2 = 0, \qquad (8)$$

$$\frac{2(W + \Delta_{xy} v_2 + \Delta_{yz} v + \Delta_{zb} v_4)\Delta_{yz}}{\Delta_{ax}^2} + 2v_3 = 0, \qquad (9)$$

$$\frac{2(W + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4)\Delta_{zb}}{\Delta_{ax}^2} + 2v_4 = 0. \qquad (10)$$

From which $\frac{v_2}{\Delta_{xy}} = \frac{v_3}{\Delta_{yz}} = \frac{v_4}{\Delta_{zb}}$, and since (5) and (6) are symmetrical, equals also $\frac{v_1}{\Delta_{ax}}$.

Substituting for v_2, v_3, v_4 in equation (5) and putting

$$K = -\frac{W}{\Delta_{ax}^2 + \Delta_{xy}^2 + \Delta_{yz}^2 + \Delta_{zb}^2},$$
$$v_1 = K\Delta_{ax},$$
$$v_2 = K\Delta_{xy},$$
$$v_3 = K\Delta_{yz},$$
$$v_4 = K\Delta_{zb},$$

and substituting these in (1), (2), (3) and (4), we get the differences of longitude $L_a - L_x$, $L_x - L_y$, $L_y - L_z$ and $L_z - L_b$.

Should the vessel after leaving B return to X, Y, or Z, and thence to a position of known longitude, each trip will give another equation of the form of (1), (2), (3) and (4), and each round trip, from a known

position to the same or another known position, or from an unknown to the same unknown, will give an equation of condition of the form of (5), and these may be proceeded with in two ways:

1. These several equations of condition may be substituted in the general least square equation

$$v_1^2 + v_2^2 + v_3^2 \quad . \quad . \quad . \quad . \quad + v_n^2 = \text{a minimum},$$

eliminating as many of the v's as there are equations of condition, thence differentiate, equate to zero and proceed as in (8), (9), (10), etc.; or

2. Take each round trip, as explained above, as a separate problem, and solve for the v's and the longitudes, and take the weighted mean of the longitudes as the true longitude. The appropriate weight in this case would be the reciprocal of the square of the time occupied in the round trip.

For the case of the Alert, referring to the previous notation table, we have:

Station.	Longitude.	Correction to L. M. T.	Interval.	Rate.
Nagasaki	L_a	C_a'		
			Δ_{ax}	$(R_{ax} = r_x) + v_1$
Chemulpo	L_x	C_x		
			Δ_x	r_x
Chemulpo	L_x	C_x'		
			Δ_{xy}	$[R_{xy} = \frac{1}{2}(r_x + r_y)] + v_2$
Keum River	L_y	C_y		
			Δ_y	r_y
Keum River	L_y	C_y'		
			Δ_{yb}	$(R_{yb} = r_y) + v_3$
Nagasaki	L_a	C_b		

$$C_a' + \Delta_{ax}(r_x + v_1) + L_a - L_x - C_x = 0, \tag{1}$$

$$C_x' + \Delta_{xy}[\tfrac{1}{2}(r_x + r_y) + v_2] + L_x - L_y - C_y = 0, \tag{2}$$

$$C_y' + \Delta_{yb}(r_y + v_3) + L_y - L_a - C_b = 0, \tag{3}$$

$$W = C_a' + C_x' + C_y' + \Delta_{ax} r_x + \frac{\Delta_{xy} r_x}{2} + \frac{\Delta_{xy} r_y}{2} + \Delta_{yb} r_y - C_x - C_y - C_b,$$

$$W + \Delta_{ax} v_1 + \Delta_{xy} v_2 + \Delta_{yb} v_3 = 0, \tag{5}$$

$$K = -\frac{W}{\Delta_{ax}^2 + \Delta_{xy}^2 + \Delta_{yb}^2} \text{ and } v_1 = K\Delta_{ax},$$

$$v_2 = K\Delta_{xy},$$

$$v_3 = K\Delta_{yb}.$$

Computation of Longitudes, Keum River and Chemulpo.

	1349 Negus.	1636 Negus.	1458 Negus.	372 Hutton.	2171 Poole.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
C'_a	— 15 21 09.8	— 15 22 43.5	— 15 05 21.3	— 15 19 00.3	— 15 23 01.8
C_x	— 15 34 26.0	— 15 36 07.5	— 15 18 25.5	— 15 32 17	— 15 36 06.5
C'_x	— 15 34 40	— 15 36 29.7	— 15 18 27.5	— 15 32 32.5	— 15 36 11.5
C_y	— 15 34 44.5	— 15 36 35	— 15 18 11	— 15 32 29.5	— 15 35 56
C'_y	— 15 34 58.2	— 15 36 42	— 15 18 05.7	— 15 32 31.5	— 15 35 50
C_b	— 15 22 25.8	— 15 34 03.7	— 15 05 18.5	— 15 19 48.5	— 15 23 02.8
Δ_{ax}	12.5 days.	12.5 days.	12.5 days.	12.5 days.	12.5 days.
Δ_x	11 "	11 "	11 "	11 "	11 "
Δ_{xy}	15 "	15 "	15 "	15 "	15 "
Δ_y	11 "	11 "	11 "	11 "	11 "
Δ_{yb}	10.5 "	10.5 "	10.5 "	10.5 "	10.5 "
$R_{ax} = r_x$	— 1.27272 s.	— 2.01818 s.	— 0.18181 s.	— 1.40909 s.	— 0.45454 s.
$R_{xy} = \frac{r + r_y}{2}$	— 1.25909 "	— 1.32727 "	+ 0.15000 "	— 0.79545 "	+ 0.04545 "
$R_{yb} = r_y$	— 1.24545 "	— 0.63636 "	+ 0.48181 "	— 0.18181 "	+ 0.54545 "
W	+ 0.42727 "	— 0.81818 "	+ 5.53636 "	— 0.95454 "	+ 2.72727 "
K log	6.93918*n*	7.22133	8.05170*n*	7.28828	7.74422*n*
v_1	— 0.01086 s.	+ 0.02081 s.	— 0.14080 s.	+ 0.02428 s.	— 0.06936 s.
v_2	— 0.01304 "	+ 0.02497 "	— 0.16895 "	+ 0.02913 "	— 0.08324 "
v_3	— 0.00913 "	+ 0.01748 "	— 0.11827 "	+ 0.02029 "	— 0.05827 "
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
$L_a - L_x$	+ 0 13 00.2	+ 0 12 59.0	+ 0 13 00.2	+ 0 12 59.4	+ 0 12 58.2
$L_x - L_y$	— 0 00 14.6	— 0 00 14.2	— 0 00 16.8	— 0 00 14.5	— 0 00 16.1
$L_y - L_a$	— 0 12 45.6	— 0 12 44.8	— 0 12 43.4	— 0 12 44.9	— 0 12 42.1

Mean Values.

$L_a - L_x$ + 0h. 12m. 59.40s.
$L_x - L_y$ — 0 00 15.24
$L_y - L_a$ — 0 12 44.16

Assuming L_a, the longitude of the observation spot, Akanura Factory, Nagasaki, Japan = 8h. 39m. 24.87s. E., then, applying the mean values, we have

Long. So Wolni Island, Chemulpo, Korea,

L_x = 8h. 26m. 25.47s. E. ± 0.23s.

Long. Changoom Head, Keum River, Korea,

L_y = 8h. 26m. 40.71s. E. ± 0.42s.

Though no observations for rate were taken at the origin of longitudes, and all the chronometers but one suffered great changes of rate, the sign of the rate in two of them being changed, the agreement in the results by the different chronometers is most satisfactory.

It is believed that the use of the above method will be less laborious for the surveying officer than the old methods, as well as enabling him to arrive at valuable results from observations that would otherwise be worthless.

The question of weights is not mentioned above, but it may be shown that equation (6) is really weighted as it should be. Thus, if the observation equations (1), (2), (3), and (4) are reduced to the same weight by dividing them by Δ_{ax}, Δ_{xy}, Δ_{yz} and Δ_{zb} respectively, v_1, v_2, v_3, and v_4 will be the residuals, and equation (6) will express the general least square equation,

$$[pvv] = \text{a minimum.}$$

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FEBRUARY 2, 1888.

COMMANDER P. F. HARRINGTON, U. S. NAVY, in the Chair.

THREE CONSIDERED AS A TACTICAL UNIT.

By LIEUTENANT D. H. MAHAN, U. S. Navy.

I.—INFANTRY.

In bringing this subject to the notice of the Institute I am actuated by the feeling that the tactics now in use are not adequate for the present day. This inadequacy has been brought about by the entire change in weapons for offensive and defensive work. Rapid-fire cannon will soon be the rule and not the exception, and the magazine rifle will, I think, soon be in general use. A man armed with one of these rifles becomes as much more dangerous as the number of charges in the magazine supplied to him is increased.

Before proceeding farther I should like to read a few extracts from a lecture delivered by Col. J. H. A. Macdonald, Commandant, Queen's Volunteer Brigade of Edinburgh; it contains many very interesting and important points apart from those I wish to bring to your notice. He says:

"Is it possible, in this day of long range rapid firing, to move either the log of the column or the plank of the line so as morally to impress the enemy, or physically to force him off his ground by a continuous advance in a shoulder-to-shoulder fashion? The thing is impossible. The force must move forward in separate portions, feeding the fighting line and bringing it up to the strength necessary for shock. Can this be done by the present style of drill, by the march past, or by the dress parade? If it cannot be done, then our present system of drill is wrong, for we think more of the parade than of efficiency, and appearances are aimed at instead of realities. Time spent on that which is unavailable for use is time wasted; habits acquired which are not consistent with comparative conditions are harmful and dangerous habits. If reliance on touch is made a soldier's second nature,

his *morale* will suffer when he finds that that on which he has been taught to rely is never available. General Wolseley says, 'I think it a very dangerous thing to teach a soldier in peace anything which he is not likely to practice in war.' Whatever has been made a man's second nature will come out when his nerve is tried. How different from the old touch and parade movement is the advance in battle of the present day! The actual advance under fire may be two miles or more, which must be covered at speed, and when a counter or flank attack must necessarily, as Von Moltke points out, move upon an arc of a circle of several miles radius before it can commence to develop its attack. An interval order, besides being most suitable for the conditions of modern fire, saves from all unnecessary fatigue. There is no straining after mathematical accuracy. There is no jostling and pressing. One may say, But if we give up the parades and fancy drills how shall we employ the men's time? Let such a one consider what Prince Hohenlohe says, 'One should not attempt artificial combinations, but rather spend the time in repeating the simple routine [by which the context shows he means a real action exercise] hundreds and thousands of times. Thus, and thus only, can you feel sure that what you require will be done before the enemy.' Men moving with an interval between them can be drilled, and have been drilled, to as great steadiness and accuracy of movement as they have ever been brought to in close files. Troops should be trained to move as accurately, as strictly, and as firmly in discipline in open order as they now do in close files. Thus, and thus only, will they safely acquire the flexibility of the action exercise, controlled by strict discipline, and yet modified by an intelligent application of the drill to its work, thus enabling the officer to keep his implements of warfare under control.

"The following are some points which demand attention in adapting infantry drill to modern requirements:

"1. A simplification of the formations, giving the utmost freedom of movement and developing an individual order.

"2. All infantry work to be studied in relation to the character of the modern warfare; the hard and fast line which now separates the parade drill from the practical exercise being removed, and rapid and frequent change from the one to the other being a distinct feature of the training.

"3. A general principle for advancing into action which would apply to all bodies of men, large and small, so as to maintain cohesion from the highest officer down to the single private.

"4. A direct movement after the troops were deployed for action, so that they should not be required to manœuvre under the terrible fire of modern weapons, but should be free to push forward as required according to the ground.

"5. Adjustment of all details, so as to give speed of movement, while saving the troops from all unnecessary fatigue.

"6. In addition, a thorough command, a development of comradeship in small groups, giving rallying power to small parties. This is the essence of restoring order in large bodies suffering from disintegration during the conflict.

"7. Training in the athletic sense to be a distinct aim in all drill.

"8. Knowing what we can do as soldiers, we shall lose our advantage if we do not take the lead of others, and we can only do so by promptly deciding how far we may, with prudence, develop our drill in a new direction, and then boldly and unhesitatingly taking the step our own judgment commends with independence and courage."

The first and sixth of these points first called my attention to the possibility of three being an important factor in the tactics of the future. In many other instances we find three as a factor of much importance. In the human body we have the head, with the two legs as motive power and the two arms as weapons of defense. In the fleet we have the centre, with the van and rear. In infantry drill we find the captain and two lieutenants assigned to the company, the one acting as the head, the other carrying out what the head commands. Taking three men now as the unit, these three are to work continually together, although separated by slight intervals when in battle action. By the combination of threes the successive gradations are made, increasing to the section, the company, battalion, regiment, brigade, division, and army corps if desired.

Beginning with three men, they should be "trained in the athletic sense," and taught all possible movements in open order as well as in close order. Having become habituated to this, they may (by joining several units) be formed into the section; the section to be composed of three units of three for the front rank, as also three units of three for the rear rank. Hence a unit equals three men; a group equals six men or two units, one front rank, the other rear rank. In the section the same mode of drill should be continued, attention being paid while in the open order more to the way of performing the movements than to the mathematical accuracy of the interval. From a combination of three sections the company is formed; so we have for the company three sections, each composed of three units for each rank,

or a total of 18 men. To every section it is desirable to allow three non-commissioned officers, call them sergeants or corporals as you please. Having combined the three sections, we have a company of 54 privates and 9 non-commissioned officers, or a total of 63 men. The officers assigned should be a captain and two lieutenants.

By the combination of three companies the battalion is formed. The regiment (brigade for naval work) would consist of three battalions. This, I think, is as far as is necessary for the combination to extend for the naval branch of the military force ; increasing, however, as shown in the following table, for the organization of an army :

Organization.	Privates.	N. C. Offs.	N. C. Staff.	Officers.		
				Company.	Staff.	Field.
Company, peace	54	9	...	3	...	...
" war	108	9	...	3	...	...
Battalion, peace	162	27	3	9	2	1
" war	324	27	3	9	2	1
Regiment or N. Brigade, peace	486	81	12	27	8	5
Regiment or N. Brigade, war	972	81	12	27	8	5
Brigade, peace	1458	243	36	81	24	15
" war	2916	243	36	81	24	15
Division, peace	4374	729	108	243	72	45
" war	8748	729	108	243	72	45

The company shall consist of 1 captain, 2 lieutenants, 6 sergeants, 3 corporals, 54 or 108 privates.

The battalion shall consist of 1 major, 1 battalion adjutant, 1 battalion quartermaster, 1 battalion sergeant-major, 1 battalion quartermaster-sergeant, 1 battalion commissary sergeant, and three complete companies.

The regiment or naval brigade shall consist of 1 colonel, 1 lieutenant-colonel, 3 majors, 27 captains and lieutenants, 2 surgeons, 1 adjutant, 1 quartermaster and commissary, 1 sergeant-major, 1 quartermaster-sergeant, 1 commissary sergeant, 3 battalion sergeant-majors, 3 battalion quartermaster-sergeants, 3 battalion commissary sergeants, 54 sergeants, 27 corporals, and 486 or 972 privates.

The brigade shall consist of 1 brigadier-general, 1 assistant adjutant-general, 1 chief commissary, 1 chief quartermaster, 1 surgeon in chief, 6 surgeons, 2 aides to general, 7 hospital stewards, and 3 full regiments.

The division shall consist of 1 major-general, 1 adjutant-general, 1 chief quartermaster, 1 chief commissary, 1 inspector-general, 1 chief engineer, 1 medical director, 1 chief of ordnance, 3 aides to major-general, and 3 full brigades and brigade staffs.

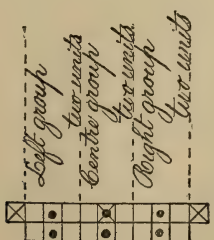
An aide can be added for Naval Brigade.

To the Division should be added an Ambulance Corps of 30 men capable of division into parties of 10 men each for brigades if necessary.

Let us consider what is necessary to work up to the movements in open order or battle action. The recruit, after his setting up drill has been completed, should be taught the facings, right, left, and about, both on the march and at a halt. In the unit of three he should be drilled both in open and close order, in changing direction at double time and at quick time, to such orders as these: "To the right (left or rear), march"; remembering always that "they should be trained to move as accurately, as strictly, and as firmly in discipline in open order as they now do in close files."

The movements of the unit then, both for close and open order, are these: "To the right (rear or left), march"; "right (or left) oblique, march"; "halt"; "right (left or about) face"; "forward (backward or double time) march"; and "deploy." This last will need explanation. Deploy is used here as the word of command which causes the units or groups to pass from the close to the interval order, or, in other words, it brings the men from a position such that their elbows touch, to one in which they are from three to five paces apart. The deploy will be executed in the following way: For the unit the centre man will advance straight to the front, the right man moves quickly to the right and front until he has attained three or five paces from the centre man, the left man moves quickly to the left and front until he has also attained the same distance from the centre man, then all move forward until the order halt. For the group, the front rank moves as above; the rear rank unit runs quickly to the left and front about fifteen paces and then deploys in same manner as front rank unit. Passing now from the unit and group to the first combination of three or the section, we find the units and groups arranged as follows:

Rear units.



Front units.

Officers N.C. officers Unit leaders.

In this drill it is desired that there should be no fixed front rank; whichever rank happens to be in front is the front rank, the other the rear rank. Then for the section or company marching in column, if the order be given "To the right (or left) front into line," it will make no difference whether the section or company is marching right or left in front, for there will be the section or company formed in section or company front with the centre group or centre section in the centre, and one group or one section on the right and one on the left. The same men still form the division line between the groups and sections, and it is only necessary for the lieutenants to keep their wits about them.

It is proposed now to manœuvre this section in all necessary ways, and to arrange a systematic tactics so that, having these manœuvres, they may be as applicable to the company, battalion, and brigade as they are to the section itself. The changes of direction for a section should be made always by a "To the right (or left), march"; "Groups right (or left), march"; "Sections right (or left), march"; the first being a flank movement and the two last wheels. If at a halt the first order would change to "Right (or left) face." With "Column right (or left), march," one will be enabled to manœuvre the section into any position required. All changes to the rear are to be performed by either "about face," or "to the rear, march." It is not desired to wheel by groups to the rear.

The foregoing are the close order movements, but they can be used as well with the open or battle order. To arrive at the open order it will be best to deploy the section into the group formation, and preferably on the centre group; however, that can be left to the discretion of the commanding officer. The order will be as follows: "On the centre group, for battle action, double time, march." (See Plate I.) The centre group moves forward at quick time, the right and left groups oblique respectively to the right and left at double time about 18 (or 30) paces and come up abreast the centre group, when they take quick time. On reaching the group lines the non-commissioned officers, who have thus far conducted the right and left groups, fall to the rear 10 paces and exercise supervision over their respective groups; the lieutenant in charge of section, while commanding all, looks out principally for the centre group. The advance in groups continues until such time as the officer in command deems it advisable to "deploy." Upon this order being given, either by word or bugle, each group will separate in the following way: The front

unit of each group will advance, the centre man forward, the right man right oblique, the left man left oblique, until each man is separated from the centre man by 3 (or 5) paces. The rear unit will oblique quickly to the left and deploy in same manner as front unit, coming into the interval on the left of each front unit. Each unit will then occupy a space of 9 (or 15) paces. The centre man of each unit $\boxed{\bullet}$ will be the leading man of that unit; if it is desired to concentrate fire on any one spot he will be the one to direct and to give the word to fire. If the members of fire line rally to fire, as soon as their fire has been delivered they will immediately deploy, keeping in motion (unless under cover) as much as possible so as to disconcert the enemy's fire.

Should the order be "On the right (or left) group, for battle action, double time, march" (see Plate II.), the right (or left) group moves forward at quick time, the others oblique at double time to the left (or right) until the centre group has proceeded 18 (or 30) paces and the left (or right) group 36 (or 60) paces, and then forward until abreast of group on which deployed. The deployment of units takes place when desired. If the section should be marching by the flank, say, for instance, on a road, and a field should be reached which it would be desirable to occupy, the command would be, "To the left (or right) front into line, for battle action, double time, march." (See Plate III.) The leading group forms into group front, the centre group coming into position 18 (or 30) paces to the left (or right) of the leading group, and the rear group 36 (or 60) paces to the left (or right) of leading group. In one instance the rear rank would be in front, but it would not change the men, as the same three always act together with the same man as the centre man, and the deploy movement is always the same, that is, the front rank unit deploys forward, the rear rank unit to the left and forward.

The section should be drilled in all the movements as though in close order: to wheel, to march by the flank, to advance and to retreat. To rally by threes and by sixes for unit or group volleys, and to deploy as soon as the fire has been delivered. To advance by rushes of 10 paces, the front rank units to advance while the rear rank units open fire; as soon as the front rank commences to fire the rear rank is to advance, passing the front rank by 20 or 30 paces and taking advantage of any possible shelter. In all these advances by rushes *the three* should be the only element of accuracy; the leader of each unit, however, being careful that he does not get too far in

advance of the line. The assemblies or rallies should not take place at the same time along the line; in some cases the guide of a group might rally the front and rear units (the rally should then be made on the leader of front unit, unless better cover could be found; the guide in that case should proceed to that cover and have the units rally or assemble on himself). No rigid rule can be laid down for any of these manœuvres, but I think it may be said that the day of rallying by companies is nearly over. Sir Lumley Graham says: "Good infantry need not fear the attack of cavalry, even if in extended order. As a general rule they should be able to maintain the formation in which they happen to be when threatened. To do otherwise would only be to play the enemy's game." By massing the troops you make a larger target and expose yourself to a greater percentage of loss. A man when compelled to depend upon himself will generally retain his self-possession; but rally them and let a panic of firing commence, the men will lose their coolness and it will take them some time after the deploy to calm down.

Having seen that the deployments can be made in any way in advance, deployments by the flank should be noticed, and also a deployment to the rear in order to provide for a surprise, when deployment to the front or flanks might be impossible. By looking carefully at the deployments marked *A* and *B* (see Plate IV.), it will be seen that after the deployments and the order "halt" is given the men will occupy the same relative positions.

To deploy to one flank, or to both flanks, the order will be, "For battle action, to the right (or left) flanks, double time, march," and will designate the evolution which is to be performed.

Let us consider the section deploying in obedience to this order, "For battle action, to the left flank, double time, march." At the order "to the left flank" the section, with the exception of the right guide, faces to the left, the left guide placing himself in front of the rear rank. At the order "march" the left guide steps off at double time, followed at intervals of 3 (or 5) paces by the left man of the left rear unit, he in turn followed by the centre man of same unit, and he by the right man of same unit. As soon as the rear unit has passed ahead, the front unit deploys in the same way; then rear centre unit, front centre unit, rear right unit, front right unit. At the order "halt" the men face to the front, guides stepping to rear.

Should the order be "to the right flank," the left guide stands fast, the others face to right. At order "march" the right guide steps

off at double time, followed by front right unit, then rear right unit, etc., at intervals of three (or five) paces.

Should the order be "to the right and left flanks," the section would deploy on the centre front rank leader. The left flank would consist of all the left group, the rear unit of centre group, and the left man of the front centre unit; all these will face to left. The right flank would consist of right group and the right front rank man of centre group; these would face to right. Led by the respective guides, they would take up the double time at intervals of 3 (or 5) paces at the order "march."

The assembly will be performed on the centre man, the left guide, or the right guide, as the case may be. The centre man is always in position. The guide named as the one on whom the assembly will be made advances at once to the battle line, and on him the men assemble.

The deployment to the rear will be, "For battle action, on centre (right or left) section (or company), to the rear, double time, march"; or "to the rear, deploy." If the first order is given, the men face to rear at the order "to the rear," and then deploy as provided for in deployment in advance. If the second order is given, the men deploy at once; the centre group is *the one* on which the deployment is *always* made when this order is given. The retreat is continued until the order halt is given. At "halt" the men face about and fire on the advancing enemy; if the retreat is to be continued, the front units will continue the fire, the rear units moving 10 paces at double time to the rear, then the front units, and so on. If the order "halt" be now given, the line is formed on that portion nearest the enemy. The only change made is a gain of 9 (or 15) paces to the right in the retreat movement (see Plate IV.).

In the drill of the section the system of three is still carried out, the lieutenant and two non-commissioned officers bearing the same relation to one another as the captain and two lieutenants.

So far the drill has been for troops in double rank. As many favor a single rank formation, it only remains to be said that if drilling in single rank, the distance between groups would have to be diminished. I prefer the double rank formation, as it is the intention to deploy into the battle or single line at a sufficient distance from the enemy to prevent the disadvantages of the double line.

In summing up, then, for the section I have endeavored (as desired in the sixth point) to have a "thorough command" throughout,

with "a development of comradeship in small groups," and also "to give the rallying power to small parties," which "is the essence of restoring order in large bodies suffering from disintegration during the conflict."

The Company.

Passing now from the section to the company, or the second combination of threes, the company is found to consist of three complete sections, that is, of 54 privates, 9 non-commissioned officers, and 3 officers—one captain and two lieutenants.

The formation (see Plate V.) shows the company as facing to the front. Immediately on the company being formed it will be the duty of the lieutenants to divide the company into the three sections, thus doing away with counting off. The first lieutenant counts from the right of the company nine and there indicates the left of the right section and the right of the centre section; the second lieutenant now takes up the count, and counting nine shows the division between the centre and left sections. The men have no numbers to remember, and the file closers, marching directly in the rear of dividing line, will see those divisions strictly carried out. In case of an incomplete number the left rear rank unit will either be incomplete or omitted. The right and centre groups of sections must be held complete throughout in every organization. In case of marching "to the rear," or of "about face," the left unit always comes into front rank. In counting off the sections the lieutenants count one, two, three; one, two, three; one, two, three. No. 2 is always centre man. If thought best, a guide can be put in the front rank at each point of division; then the right guides of all sections and the left guide of the extreme left section will always be in place. This, however, is not considered necessary.

In addition to the movements of the section, we require to deploy the company into the open order. The company being faced to the front, command, "On the centre section for battle action, double time, march." (See Plate V.) At the order "march" the centre section under the immediate command of the captain moves forward, quick time. The right section under command of the first lieutenant, and the left section under command of the second lieutenant, move respectively to the right and left oblique at double time until 54 (or 90) paces from the centre section and abreast of it, when they will take the quick time. Each officer gives the command, then, "On the centre group, for battle action, double time, march." This is

performed as shown previously. The order "deploy" will be given by the captain whenever necessary. The advances when the company is deployed will be by rushes of sections, the officers in command giving the order to advance. The centre rushes first, covered by the fire of the right and left sections, followed by both the right and left, or, if the opposing fire is very heavy, by only one section at a time. As has been said before, there can be no fixed rule given as to the time to start the rushes, which section to advance first, or how far to advance.

In case of a surprise, and a sudden deployment into the battle line be necessary, the order will be "Deploy into battle action." At this order each leader of a unit will start to right, left, or forward, as the case may be, followed by his two flanking men, separating, however, to a slight extent. After a little practice it will be found that the men will appear in about their proper intervals and places in the battle line. Proper shelter is the first thing a unit leader should look for in case of a deployment by reason of a surprise. For the company there may be a few other developments, but, since simplification of both formation and evolution is sought after, they should be confined to two or three in addition to those already mentioned. The same order can be used whether the company is moving by the flank or in column of groups or sections, and it is desired to bring it into company front, *i. e.*, "To the right (or left) front into line," and also "On the right (or left) into line." In all these movements the centre is always the centre, and in the manœuvring much depends on the captain and lieutenants. In all rally and assembly formations the men repair on the run to their proper positions in whatever formation has been ordered. The rally should mean only one volley and then deploy. Any assembly should be deployed by the officer ordering the assembly. With the men on the firing line, neither the rally nor the assembly is favored. The unit or group may be allowed to rally or assemble for a concentrating fire if sufficient cover offer.

The Battalion.

The battalion is the third combination of three, or, in other words, a battalion consists of three companies. The officers and non-commissioned officers of the battalion are three times those of the company, and in addition thereto, one major in command, one adjutant, one doctor, one sergeant-major, and one quartermaster-sergeant.

The manœuvres of the battalion should approach as near as possible to those of the company and the section, with the addition of a few necessary for the management of so large a body of men. On the simple manœuvres it is unnecessary to dwell, so let us turn our attention to the interval or battle order for the battalion. The first order given, " On the centre (right or left) company, for battle action, double time, march," will designate the company which is to make the forward movement. The others will move as given in the case of sections from a company, only the intervals will be 162 (or 270) paces between companies. As soon as these positions are gained, company officers will deploy in section formation, then into group, and finally, when necessary, into the firing line. At this time we have the battalion (which from a far off distance has been gradually approaching the enemy, and which, as the danger of casualty increased, has been gradually reducing the size of the body opposed to the enemy's fire) ready at a signal to throw each man on his own resources as it were, or, in other words, to form a single line of skirmishers 3 (or 5) paces apart. In this I think is nearly solved the third point, which requires " a general principle for advancing into action which would apply to all bodies of men, large or small, so as to maintain cohesion from the highest officer down to the single private." By looking a little closer it will be seen that the major has his three captains; they in turn exert an influence, with the aid of their lieutenants, over the companies; the captain and lieutenants, with the aid of non-commissioned officers, over the sections, each one of the officers and non-commissioned officers over a group, and when a group is deployed there remains the cohesion of the three men forming the unit or factor for tactical work.

It must be remembered that as soon as the groups are deployed the rushes must commence, for by this time it is supposable that the line of fire, which the battalion has now become, has approached so near the enemy as to render it necessary to take advantage of any shelter possible. Now comes in the advantage of supporting one another. The three working together gives to each one of them more confidence, for each feels that he has two pairs of eyes besides his own to guard against surprise. In falling back the groups should not be assembled until well away from the zone of fire; then assemble by groups, sections, companies, and finally to the battalion. The assemblies should always be made towards the centres. Groups assemble from the fire line on the centre man of the front unit, the

man on whom they deployed. Sections rally or assemble on the centre group; companies on the centre section, and battalions on the centre company. The preceding mode of deployment is one that could be used over an open space from the battalion either drawn up in line of battle or in column of companies. If in column of companies, the first order would be "Companies to the right (or left) for battle action, double time, march." As soon as this order had been carried out the other orders would follow as before. Suppose, however, that the battalion was in column of companies and the space was too limited to allow the whole battalion to be deployed as just described, but it was *necessary* to get as many men as possible into the firing line, the following would have to be resorted to. Deploy the leading company as usual. As soon as it has reached the group formation, deploy the second company; as soon as it reaches the group line deploy the third company; the major going into action with the third company. The fire line in this instance would be three deep, separated by from 10 to 20 paces. The first and second line do the fighting, the third line being held in reserve. To facilitate the advance the second line should open a heavy fire, under cover of which the first line should rush as far as possible; the first line takes up the fire, and the second and third lines advance into their new positions. This continues until such time as an assault can be attempted. Previous to the assault, however, when the first can no longer advance unaided, both the second and third lines should be advanced to the first. This agrees with what Sir Lumley Graham says: "For the front or 'firing line,' the only formation, both in attack and defense, which meets these requirements, is a line of small sections extended in single rank, which from being at first very open becomes more and more dense as the antagonists come to close quarters, attaining at last almost the consistency of a line in close order." Having considered the most necessary manœuvres for the battalion, what other means may be necessary to change its direction and fronts? Such a battalion as this occupies but little space, and it can be massed, when not too near the enemy, into a very small compass. Closed in column of companies, its direction can be easily changed by wheels or by flank movements. To change fronts, by a flank movement followed by a file to the left or right. To pass obstacles, by a movement to the rear and left or right of any section or sections, company or companies. The deployment of the closed column will have to be performed as circumstances may dictate, but

for all such manœuvres the present style of tactics will suffice. In all movements a battalion is a battalion whether composed of three companies as herein advocated, or up to ten companies as provided for by Upton's tactics. If possible, all ployments and deployments should be on the centre company or battalion, as the men will have less marching and countermarching.

The Regiment or the Naval Brigade.

The regiment or the naval brigade is the fourth combination of three, and as far as infantry is concerned, no further combinations will be considered at present. Three battalions of three companies each go to make up the regiment or naval brigade. Remember, however, that we are now only considering the main body, and not the adjuncts necessary to the brigade. In addition to the battalion officers, there should be one assistant adjutant-general, one assistant commissary, one aide to colonel or chief of brigade, one staff doctor, and one colonel or chief of brigade. All evolutions for the battalion given in Upton can be performed by this body with the exception of such as require a movement by fours, and in place thereof the face or the wheel by groups will have to be used. These movements will be in close order. Movements in interval order can also be executed. Deployments into battle action will be best performed by one battalion at a time (and still better by one company at a time), in one line or three. If necessary, the whole brigade can be deployed; but it is well to have a sufficient number to support the firing line, as, to quote another's words, "the firing line has to fight out the battle through all its stages to the very conclusion, being supported in doing so by the troops in close order." Let us consider for a moment a brigade drawn up by battalions in columns of companies, and that it had been determined to attack the enemy's position by a direct attack on the centre, or by simultaneous attacks on the flanks. To commence the centre attack, the centre battalion would be deployed as already described, the right and left battalions being held in readiness for the final assault. Before that time, these two battalions should be deployed so as to cover the flanks of the centre battalion to some extent, and their advance so regulated as to join forces close behind the centre battalion at the moment of assault.

Should the attack be simultaneous on the centre and the flanks, the right and left battalions would have to be manœuvred so as to com-

mand the left and right flanks of the enemy. The advances would also have to be made with some degree of dependence upon each other, so as to assault as nearly at the same time as possible. Should neither of these attacks be practicable, the centre battalion could attack as before; and as soon as they had succeeded in silencing the enemy's fire to some extent, the remaining battalions could attempt the assault. In this last it is to be presumed that the loss would be much heavier from the fact of having crossed the zone of fire in a compact mass. There is one evolution that should not be attempted, and that is, forming a square or rallying by companies to resist cavalry. Rather receive such an attack in echelon of companies, with a section from each company deployed as skirmishers, if only one battalion is engaged; if the brigade is threatened, form line of battle with centre battalion, deploy centre company thereof, form right and left battalions in echelon of companies on respective flanks of centre battalion (see Plate VI.). The blocks show the companies of the centre battalion in line of battle; the dots, the centre company in firing line; the right and left wings in echelon of companies. The arrows show the positions of cavalry. *A* shows movement of left wing with cavalry at *A* ⇓. *B* shows the movements of same wing with cavalry at *B* ⇓. The left wing either moving up to B^1, B^2, B^3, if there is time, or facing about and making a half wheel previous to delivering fire. The arrows on the battle line show the direction of movement.

The battalions are now so situated that every rifle can be used against the approaching cavalry. The battle line will meet the first charge of the cavalry, and if armed with magazine rifles will do it much damage. The battalions are in such a position that, should the cavalry change its original plan and attempt a flank movement, they could by an *advance* movement change front on the advancing enemy and thoroughly protect both flanks. This formation is favored because it allows of the use of every rifle, because every man on the defensive has a chance to see what the enemy is about to do and cannot be taken unawares, and because it allows, by a sudden change of front, a chance of enfilading the attacking party.

In concluding these remarks on infantry as affected by the factor three, I would like to quote a few words from some authorities in support of my position.

From Sir Lumley Graham's work:

"The formation of infantry for battle must be such as to favor to

the utmost the effect of its own fire, and to minimize the damage done by the enemy."

"The comparatively loose formations necessary in the present day render supervision and control on the part of superiors more difficult. Tactical dispositions will again do something to remedy this evil, but thorough discipline and training will do more, contributing, as they will, to the complete maintenance of the chain of responsibility from the commander-in-chief right down to the leader of the smallest squads in the fighting line."

"Continual practice must be had to enable one to take advantage of the ideas taught."

From Upton: "The want of a system whereby the information and experience acquired in one arm of the service may be made available in the others has long been felt in the army" [navy]. "To make the assimilation as perfect as possible, many changes have been made in the infantry tactics, the reasons for which will appear upon referring to the corresponding movements in the artillery and cavalry" [boats].

From an article written by Captain A. P. du Sonich: "Notwithstanding all the perfections in arms that infantry can show, the cannon will remain the regulator of the fight. It will force masses to deploy, and it is only when these masses are transformed into thin but compact lines that the rifle will show its efficiency."

From "Regulations for Austrian Artillery," by changing a few words: "As a principle, all movements in advance are made in the shape of a fan, on the centre; it is only deployed in one direction unless the ground requires it. The changes of front are executed on a battery [company] designated, most often on the centre."

This ends the consideration of infantry for the time being; enough has been said to show that the plan will work, and that it simplifies all movements. I shall next consider this tactical unit in relation to artillery, boats, and ships.

II.—Artillery.

In organizing the artillery battalion, the size of the company should be the same as in the infantry battalion, viz., 54 privates, 9 non-commissioned officers, 1 captain, and 2 lieutenants. The piece with the limber should be provided with a double drag rope, and the centre and left sections should man it, the right section acting as skirmishers or infantry support if necessary (see Plate VII.). This would give a

sufficient number to drag the piece over almost any obstruction that might offer, and at the same time assuring a number capable of making a desperate resistance against capture. Should the march be over easy ground for a short distance, and extra artillery be necessary, the supply could be doubled, the centre section taking one piece, the left the second piece, and the right again acting as infantry support (see Plate VIII.).

On the march the right could relieve the centre at some convenient halt, and then the centre the left. In moving down hill, numbers 8 and 9 man the short drag rope. The tactics would be the same as for infantry. The "company" would comprise the same privates and officers, and the only change to be made would be in distances when marching in column and battery front. A battery should consist of three companies, corresponding to a battalion, and should be subject to the same orders and drills. In the arrangement of this battery it is desired to keep the formation of the three system as perfect as possible. The arrangement of the sections should be such that one section should always work together, be it at the drag rope, or be it in use as infantry support.

The sections used as infantry supports can be deployed as skirmishers on the flanks and in front if desired. In action these sections could be used as skirmishers on either flank of battery position. In working the gun, if a single piece to a company, the centre section would work the gun, the left and right sections being used as infantry. If two pieces to a company, the centre and left would handle a piece each; the right would be as infantry. In working the section the three groups would have specified duties. The left group would serve the piece, the centre group would act as ammunition passers, the right group as guards for limber; both the centre and right groups would run the limber to cover at the order, "In action." In case only one gun was used, as soon as the limber was safe to the rear the left section would be marched under cover a short distance from the gun. If skirmishers had to be deployed to resist a threatened attack, both the left and right sections could be used as such. On the drag rope the left group or groups are nearest to and around the gun, the right being at the end. The commands for the company would suffice for the one or two pieces. The commands for the battery would be similar to those for the battalion. "Companies right wheel" would wheel one or two pieces, as the case might be. "To the right, march," would wheel each piece to the right, forming a column of

single pieces; "to the left, front into line" would bring it from column to battery front; and since there would always be a right and left to every centre, each working as a single and separate organization though incorporate in a larger one, there should be no disorder, so long as the officers kept their wits about them and realized that when they are on the right they become the right company or battalion, as the case may be, and when they are on the left they become the left of the organization. The centre is always the centre; the right may become the left by giving the order, "Piece right (or left) about, march." The effort is to simplify the routine of drill and cause a few manœuvres to do for the many now in existence. As quoted once before, "the changes of front should be executed on a battery [or piece can be substituted] designated, most often on the centre," and in the same regulations we find "artillery is always supposed to be supported by infantry or cavalry." By the arrangement of sections as given in the preceding pages, the infantry support is provided in the battery itself, so that there need be no diminution of the strength of the infantry by assigning any of it to the defense of the artillery.

It will be noticed that in all formations on the march, the infantry section marches ahead of the men on the drag rope, the reason for this being to have them ready to deploy in case of need. On the march, in column, the section of the leading piece deploys on the centre group forward. The section of centre piece wheels to the right and deploys in same manner, and on arriving at a certain distance from column, changes direction by the left flank. The section of rear piece wheels to the left and deploys on left group forward, and in turn changes direction by the right flank. Thus a line of skirmishers will be formed well in front and on both flanks, while the rear is sufficiently covered to prevent surprise from that quarter.

In marching by battery front, the sections can be deployed forward and on both flanks if necessary. If the order should be "To the right, march," the pieces would wheel to the right, and the infantry section change direction by the right flank, thus keeping abreast of the pieces. If danger should be suspected and it is desired to deploy the infantry sections in the direction of the march, the order, "Battery, halt, fire to the front, in battery," should be given, and at the same time the order for the deployment of the infantry should be such as to deploy the left section on the right group, the centre on the centre group, and the right section on the left group. The pieces being "in battery," the section not working the piece immediately form

as infantry support in readiness to reinforce the firing line. The piece should not "limber up" until the firing line has advanced sufficiently far to show the non-existence of danger, or it becomes apparent that the command must retreat. If a halt is made for a meal, the firing line should be relieved by the section not working the piece as soon as it has finished its meal.

III.—Boats.

In exercise with boats there should be allowed one section to one boat's crew, and one company to three boat's crews. A section in manning boats will then have twelve rowers and six sitters, or if a piece of artillery is carried in the boat, these sitters would serve the piece. For boat exercise the captain of the company will be in the centre boat, the first lieutenant in the right boat when advancing, and the second lieutenant in the other boat. The company can be drilled as a squadron in all necessary evolutions. By combining three companies or nine boats the fleet is formed, having a van, centre, and rear, each composed of three boats. This fleet can be exercised in all tactics now applicable to boats, with a few alterations.

IV.—Naval Tactics.

In the discussion of Commander Taylor's paper on Naval Tactics, published in No. 37, Naval Institute Proceedings, on page 165, I took a fleet of nine vessels, as opposed to Commander Taylor's nine. These were arranged in cruising order, as I called it, and were formed as shown in Plate IX.; the advantage claimed for this formation being that there is no ahead and astern line, consequently less danger of collision, and the system of three is continually maintained. The centre ship is still kept as the leader of each squadron (unit), the senior in command being in the centre ship of the centre unit. On his vessel all movements could be made without his vessel being withdrawn from the squadron to which it belongs. For instance, desiring to form double column on the centre, the double column is formed on the right and left vessels of his squadron, the right and left wings being brought into position astern of those vessels. His movements are still coincident with those of his squadron, but every vessel is easily seen from the senior officer's ship, and the system of threes is still maintained. (See Plate X.)

From this formation any movement can be made. If desired to form line abeam, eight points to starboard, each vessel of the right

wing would change direction eight points to starboard; the centre would wheel eight points to starboard on the right vessel of that squadron as pivot; the left wing would continue ahead, full speed, until centre squadron was well uncovered, and then eight points to starboard and forward into line. The numbers are used so as to show that inversion takes place in the left squadron. Had the order been line abeam, eight points to port, the inversion would have taken place in the right squadron. (See Plate XI.)

An objection may be made to this that the vessels in the left squadron have been, as it were, transposed. True; but does that make any difference so long as there are three vessels in the squadron? A captain can command as well on the right as on the left. The formation which it is desired should be flexible is thus shown to be so. Again, in movements made in this way the ships remain the same distance apart, all turn to starboard at the same time, and there is no successive formation giving a possibility of accident. The successive formation is liable to accident in such a case as this: if while performing this evolution (left wing changing course to starboard one by one so as to bring No. 7 in its proper numerical place), the leading vessel should by accident starboard the helm, then quickly port it, the centre vessel, approaching at full speed, would have either to change its course or ram the leading vessel. The last would most likely be the case on account of the two changes of helm of leading vessel. This indecision on part of the leading vessel would also naturally react on the rear vessel, and so there would be three vessels out of position, all on account of a mistake possibly made by the man at the wheel of the leading vessel. In performing the evolution as given in the diagram, on the signal being hauled down by flagship of squadron, all vessels port (or starboard) their helms at the same time. If now one vessel puts its helm the wrong way it only inconveniences itself. Being in line abeam, column of squadrons can be formed right or left in front, on any squadron desired. If cruising in squadron only, the centre vessel would lead, the right and left being in double echelon on the centre vessel. I think any evolution can be performed and the system of three be kept intact.

In all that has been said it has been the endeavor to preserve three as the factor of each and every branch of tactics. There are objections, of course, to such a system, one being that a complete revolution has been attempted. It may or may not be a successful one, but that can be said of all attempted changes. The subject has been only generally treated, as it is not the intention to write a tactics.

DISCUSSION.

Lieutenant-Colonel H. S. Hawkins, U. S. A.*—I have read with much pleasure Lieutenant Mahan's paper which shows research and careful study of the very important subject of modern infantry tactics. In submitting the "opinions and criticisms" invited by the U. S. Naval Institute, I must apologize for unavoidable allusion to work of my own in the same direction.

I agree with every word quoted from Colonel Macdonald's lecture, and I can confirm the truth of his assertion that "men moving with an interval between them can be drilled, and have been drilled, to as great steadiness and accuracy of movement as they have ever been brought to in close files."

Lieutenant Mahan's proposed deployments of the group of six are very similar to the deployments of Upton's group of eight or set of fours, and I do not see that there is a marked gain in celerity. The principal criticism that I make of the proposed unit of three is the same as the objection to the present tactical unit of four, viz. that it necessitates counting off, which is practically the same whether the counting be done by the men themselves or by the lieutenant, who, according to Lieutenant Mahan's plan, counts off one, two, three; one, two, three; one, two, three. Indeed, the counting by the men is more rapid. But I would do away with counting off altogether.

In a system of infantry drill which I have prepared the men fall in in four ranks, thus:

This is called the *Column of route*, being that used for marches. The first rank is always that which is farthest from the file closers, who may be ordered to either flank of the column. The second rank is 12 inches from the first rank. The third rank is 12 inches from the second rank. The fourth rank is 12 inches from the third rank.

Each man in the first rank is 56 inches from the next preceding man in his own rank. Each man in the second rank is directly opposite an interval in the first rank. Each man in the third rank is abreast of the corresponding man in the first rank. Each man in the fourth rank is abreast of the corresponding man in the second rank. Now face the column to the left (or right) to form line. This is called the *Normal line*. The first rank is that which is in front, no matter which way the line faces. If it faces toward the file closers they pass through.

Each man in the first rank is 46 inches from the next man on his right or left. Each man in the second rank is, as before, directly opposite an interval in the first rank. The men in the third and fourth ranks simply cover their file leaders. Now close files to the front; the result is this:

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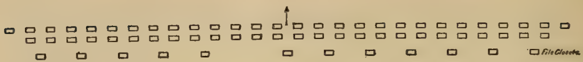

This is called *Line of two ranks.*

There is an interval of 12 inches between each two files composed of front and rear rank. The rear rank men take a side step to the right to fire through the intervals.

All movements are habitually made in *normal line* or in *column of route*, and with as much of personal comfort in one as in the other. There is no counting off. A man falls in and cannot help *seeing* what rank he is in.

To illustrate this give these three commands: *Fall in; Left face; Stack arms.* In all other systems the men must be numbered to stack arms. In this system each man *in the first rank* makes the stack, seizing the piece of the man in the second rank on his left rear with his left hand; each man in the third rank steps forward to help his file leader make the stack; the pieces in the fourth rank are loose pieces.

When desirable the men form in *column of route* with intervals of 32 inches instead of 56 inches, so that upon facing to the front and forming *line of two ranks* the men are elbow to elbow.

A company being in *normal line* the captain sends forward the first rank, *already deployed*, to open the fight; or he uses two or three ranks; or he may develop the whole company. Then again he may detach the first platoon under a lieutenant who can use it precisely as he would a full company, the other platoon being used as the main reserve.

Being in *column of route* the captain uses one or more ranks or the whole company, as circumstances require.

The deployments from *normal line* are made forward or by the flanks; to the right or to the left, or to both right and left.

No matter in what way the deployments are made, at least one entire rank can instantly open fire while the others are taking position.

The deployments from *column of route* are equally rapid.

I tried the following experiment in the presence of General Terry and General McCook, Colonel of the 6th Infantry, at Fort Leavenworth:

One hundred men were taken promiscuously from the infantry companies and told to distribute themselves like a lot of tired men will do while resting on a dusty road, of course breaking up all formation. They were told that three commands would be given, viz.: *Fall in; Deploy as skirmishers;* and *Commence firing.* They were timed by the watch. The execution of all three commands took one minute and five seconds, and these hundred men were deployed systematically nearly one hundred yards to the front, firing from shelter. With men accustomed to the drill this time can be diminished one third.

I claim that my men could be at effective work before a company of equal size could count off.

It seems to me that the simplicity of the drill and the absence of all numbering of the men are features peculiarly suited to the notions of sailors who may

be required to fight on land. Jumping ashore from the boats, the command is given to *Fall in*. The very next command may be to *Deploy as skirmishers*, or to detach one or more ranks to open the attack, without losing time to count off or to divide into sections. The act of falling in practically divides the force, whether small or large, into four sections ready for use without fnrther ado.

The rushes which Lieutenant Mahan speaks of are made by alternate ranks. The fire of each rank is controlled by its own chief, and all may be brought to bear upon one objective by direction of the chief of the *firing line*.

In all formations, whether of line or of column, at full distance or closed in mass, the men may be ordered to lie down without disturbing the formation.

But this paper is becoming longer than I intended and may prove too great a tax upon your patience.

Lieutenant D. H. MAHAN.—The counting off by threes is not necessarily required in the section, and I think that my company can form quite as readily when landing from boats, when it is considered that a section is seated in a boat in regular order and is actually forming as the men jump over the bow ashore. They can be trained to take their position in two ranks quite as readily as in four.

The section being in a boat, the order is given, "Land, deploy." The first group moves off to the right, the second advances, and the third to the left, without further orders.

I agree with Colonel Hawkins in desiring to avoid counting off, and for that reason I have given my section only nine front ; as with careful training and an average amount of sense in the men, they can by looking to the right and left easily determine their position.

In regard to stacking arms, the front-rank leader makes the stack, using the pieces on either side with his own; the rear rank lays on loose pieces. There is no moving, no reaching to the rear, and all the pieces of a group are in the same stack.

In opening the fight, the leading section can be deployed first, then the centre section, and then the remaining section ; or the whole company can be deployed.

One or two sections can be detached and each used as a company, the other sections or section being in reserve.

For example, of these two columns marching by the flank along a narrow road, which is easier, to advance skirmishers from a column in which every other man has to step out of ranks and the rear man has to run the whole length of the company, or to deploy the leading section? With Colonel Hawkins' "line of two ranks" marching by the flank, and the order, "1st rank deploy" be given, numbers 1, 3, 5, 7, up to 25 have to step out of ranks, run to the head of column and deploy. With the plan under discussion, the order "Right section to the right (or left), deploy," is given, and only the men at the head of the column deploy. I do not think in this case his rank can open fire as quickly as mine without danger to those near them.

Never having had an opportunity to practice men in my drill (such opportu-

nities being rare), I cannot say how long it would take to deploy as Colonel Hawkins describes, but I think with practice I could drill a company to pull themselves ashore and land and deploy in fully as quick time. I incline to my rushes, since I can keep up a continuous fire without as much danger to my men as in the case where rank has to pass through rank.

I am sorry not to have seen more of Colonel Hawkins' plan, as I am fighting in the dark in regard to many points. I can see no system of association in the movements described, and consequently no rallying or assembling system. A jump is made from the man to the company. It seems as if the men are left too much to themselves in the fire line ; in fact, the sixth point in my article is entirely disregarded, viz. : "In addition, a thorough command, a development of comradeship in small groups, giving rallying power to small parties. This is the *essence* of restoring order in large bodies suffering from disintegration during the conflict."

Lieutenant W. F. Fullam, U. S. N.—There are two extremes to be avoided in considering the question of tactics : first, an obstinate and unreasonable conservatism which resists all change, no matter how necessary ; second, an inordinate desire for change for the mere sake of change, with no accompanying benefit or gain in principle. Both of these extremes are dangerous—the latter more so than the former, perhaps, since ill-timed revolutions always create a great deal of unnecessary trouble. There is, however, a safe, level-headed position which should always be sought for, characterized by a perfect readiness to accept amendments whenever anything is to be gained by so doing, and a firm resistance to changes for which no good reason can be advanced.

The scheme devised by Lieutenant Mahan is most ingenious, interesting, and instructive, and the discussion of such a plan is sure to be beneficial, provided criticisms are invited and encouraged.

Lieutenant Mahan gives no reason for changing the unit from four to three, and I am not enough of a tactician to know whether a good reason exists or not. I can see none, however. Major Livermore, U. S. Army, in the discussion of the Prize Essay, says : "It is desirable to organize the regiments with twelve companies, not so much for the sake of having *three* battalions to a regiment as for the sake of having *four* companies to a battalion, and in time of war it would be well to add another battalion so as to make sixteen companies to a regiment. It would be well also to group the higher and lower units in *fours, and all European nations are coming to this conclusion.*" This is rather strong evidence of a tendency toward combinations of four instead of three.

There would appear to be one danger in this plan of organizing everything by threes—that a plan of deployment and manœuvres may be adopted with a single idea pervading it, so that the plan may not work well when other conditions of organization may necessarily exist. In other words, any system of deployment and manœuvring in battle should be so general as to be equally applicable to companies of any size, composed of two, three, or any number of sections or platoons ; to battalions composed of three or any other number of companies, and to regiments or brigades composed of any number of battalions. This requirement must be fulfilled in any system adopted for the

Navy, since all ships' battalions cannot be of the same size or be composed of the same number of companies. Two, three, five, or ten ships may land their battalions, thus forming regiments of different sizes, to each of which our tactics must be equally applicable. However ingenious the system of threes may be, therefore, it is dangerous and narrow unless it can be easily applied to all these different circumstances of organization. Major Livermore, for instance, tells us that "whatever system may be adopted in the Army, *it will be so flexible* as to be fully applicable to any grouping that may be required from time to time, for the organizations will seldom be complete, and the fractions of several units will be often united."

There seems to be a wide diversity of opinion regarding the best size for the companies in a ship's battalion, but the majority seem to think that 36 men is the proper number. If the battalion is to be built up from the gun divisions, 36 men will require less transfers, since the guns of modern ships are rather detached from each other, and the divisions will approximate more nearly to that number than to any other—more nearly than to 63, as Lieutenant Mahan proposes. The number in the different divisions on board the Boston, for instance, are: 1st Div., 35; 2d Div., 35; 3d Div., 32; 4th Div., 25; and Marine Guard, 40. By transferring a few men from the Powder and Navigator's Divisions these five companies can be filled and equalized. A front of 16 men is a convenient front to handle, particularly in a street. And right here it may be proper to say that mob and street fighting, or service in the streets of cities, is that which naval battalions are most likely to perform, and therefore more attention should be paid to it. We talk a great deal in the Navy about skirmishers and battles, but history shows very few instances of real skirmishing on the part of our naval forces, and more cases of landing for service in the streets of cities. To organize companies of 63 men would probably be very troublesome in many cases on board ship. It is seldom that the Marine Guard contains that number of men, and it is certain that the Boston's battalion would not be as efficient if organized in companies of 63 men, since the divisions would be quite broken up. Right here, then, we see that the system of threes will not work well, for instead of three sections or platoons to a company, it is more advisable to have two of eight men front forming a group of sixteen men, and it is a most convenient size for street service. In case a division on board ship contains more than 36 men, I see no reason why its company should not be increased by one group or two. If we are really going to get rid of parade principles, stiffness, and cast-iron rules that interfere with flexibility, why should all companies in the Navy be of exactly the same size? A company may land in three boats as well as in two.

As regards orders, I think Lieutenant Mahan's changes are in many cases quite unnecessary—mere changes with no gain whatever in brevity or principle. For instance, why say "section" instead of "platoon"? The latter is a good term, an old one which we all understand—every sailor is familiar with it. "To the right march" is not as good as "Right flank march," and "Sections right march" is little better than "Platoons right wheel march"—there is not gain enough in these changes to make them advisable. A change of

tactics will cause trouble enough without compelling everybody to learn a new language. To be practical and assist every officer and man to learn a new system quickly, we should retain such familiar and expressive tactical words as "platoon," "flank," and "wheel" whenever they will apply.

Compare Lieutenant Mahan's orders for deploying a company with the orders given in Upton.

Mahan.—Captain commands:—"On the centre section, for battle action, double time, march" (10 words). Afterward each lieutenant and the captain command:—"On the centre group, for battle action, double time, march" (10 words). Finally the captain commands "deploy," making in all 21 words to deploy a company. Indeed, as the second set of orders is given by *each of three different officers to each of three different sections* it ought to be counted three times, which would make 41 words. But no matter—count it once.

Upton.—Captain commands:—(1) As skirmishers, (2) On the centre four take intervals, (3) Double time, (4) March (11 words); and afterward "deploy" —total 12 words to deploy a company, while Lieutenant Mahan uses at least 21 words, or nearly twice as many. Besides, in Upton all the orders are given by the captain, which is far better than the repetition necessary in Lieutenant Mahan's method.

The principle of the deployment is essentially the same in the two cases, except that Upton's is simpler and more direct in not separating the company into sections or platoons. In other words, we have a complete change of orders, and more of them, to accomplish the same identical result. Surely such changes as these are not in the direction of greater simplicity, do not gain anything in principle, and ought to be resisted, since they would only cause unnecessary trouble to every officer and man in the acquirement of a new system of tactics.

Furthermore, in the deployment of a company, as shown in Plate V., more time would be required and every man, except those in the centre group, would probably have farther to go than in the same method of deployment provided for in par. 282, Upton's Tactics. This may be seen by drawing a straight line from each group in the company (Plate V.) to its position in the line of groups —this straight line representing very nearly the path taken by the group in deploying by Upton. Now trace in Plate V. the path of each group by Lieutenant Mahan's method, and it will be seen that in nearly every case his group travels over two sides of a triangle of which the third side (and therefore the shorter distance) is the path by Upton. Lieutenant Mahan's system of deployment is, therefore, inferior to Upton's in requiring more orders, more time, and more travel. It is all due to the fact that Upton wisely causes the fours, or groups, to diverge and take intervals *at once*, while Lieutenant Mahan first deploys the sections and then the groups, which is quite unnecessary in such a small company. Here, therefore, is one instance where the tendency to follow up the one idea of dividing everything into threes fails to result in that "simplification of formations, giving the utmost freedom of movement," etc., mentioned in Lieutenant Mahan's *Point No.* 1, and violates entirely his *Point No.* 5, "The adjustment of all details so as to give *speed of movement* while

saving the troops from *all unnecessary fatigue.*" Nor does Lieutenant Mahan's method attain *as quickly* as Upton the principle quoted from the Regulations of the Austrian Artillery, "all movements in advance are made in the shape of a fan on the centre."

Lieutenant Mahan gives a method for "sudden deployment in case of a surprise," and provides that—"At this order each leader of a unit will start to right, left, or forward, as the case may be, followed by his two flanking men . . . . . Proper shelter is the first thing a unit leader should look for in case of a deployment by reason of a surprise." To provide for a special deployment in case of surprise is to acknowledge the weakness of the ordinary method. Better consider that every case may be a surprise, if we are to be practical in the future and do away with parade drills. There is probably one system of taking intervals that is best and quickest, and that system should be used at all times. The men should not be taught to *mistrust* the ordinary method of deployments, but rather to *have faith in it* at all times and to observe it strictly. Their steadiness may then "surprise" the enemy. To use Lieutenant Mahan's quotation: "One should not attempt *artificial combinations*, but rather spend the time in *repeating* the *simple routine* hundreds and thousands of times. Thus, and thus only, can you feel sure that what you require will be done before the enemy." In other words, teach the *simplest routine* and no other; repeat it hundreds and thousands of times, and the men will be ready for every "surprise," and will not be demoralized when a sudden emergency arises. I believe that if "each leader of a unit starts off to right, left, or forward," looking for "proper shelter the *first thing*," many of them will make for the same "proper shelter," confusion and disorder will be the result, and a scramble will ensue. Even if the units keep together (which is doubtful under such instructions), the *groups* would be entirely destroyed by teaching the *units* to "start off and look for proper shelter the first thing." *It is a fatal mistake to teach men to seek shelter until after the deployment is complete*, and it is more necessary to preserve the groups in case of surprise than at any other time. A company can take intervals by Upton's Tactics in less than 30 seconds. I have, this very morning, deployed my company of 36 blue jackets forward on the centre four by Upton in 15 seconds. This is quicker than Lieutenant Mahan can do it by his ordinary method of first separating into platoons, and by cautioning the men to seek cover *after the groups get their intervals*, *thus insuring a proper length of line*, a surprise will be met by Upton far better than by Lieutenant Mahan's "surprise deployment." To sum up, the surprise deployment is dangerous in not insisting upon the preservation of the groups and a careful taking of intervals necessary to cover the front and prevent being flanked, while Upton's method would be quite quick enough, would preserve the groups or fours intact, and realize the principles of Lieutenant Mahan's *Point No.* 6—"A thorough command, a development of comradeship in small groups, giving rallying power to small parties. This is the essence of restoring order in large bodies suffering from disintegration during the conflict." Would not the surprise deployment prevent "a thorough command" and "rallying power" too, and cause "disintegration" *before* the "conflict"?

In the formation of the company it is not easy to see how any counting off is done away with, as Lieutenant Mahan claims. On the contrary it would appear that, in reality, there is quite as much counting off, if not more, by Lieutenant Mahan's method, the only difference being that the lieutenants do the counting instead of the men themselves—a change by which no principle is gained, while time is lost. Lieutenant Mahan appears to contradict himself on this point. He says "the lieutenants divide the company into three sections, *thus doing away with counting off*"; but in the next sentence he adds: "the first lieutenant *counts* from the right of the company nine and there indicates the left of the right section; the second lieutenant now takes up the *count*, and *counting* nine shows the division between the centre and left sections," and farther along we find—"*In counting off the sections the lieutenants count one, two, three; one, two, three; one, two, three.*" After asserting that counting off is done away with, Lieutenant Mahan uses the words "count" and "counting" five times, and in the last sentence quoted above he shows that the counting off is thorough and complete. Again he says, "the men have no numbers to remember," and afterwards he adds, "No. 2 is always centre man." Evidently, then, every No. 2 must be designated and must remember that he *is* No. 2, or centre man; and each of the other two men of the same unit must know and remember that he is *not* No. 2—or, in other words, that he *is* either No. 1 or No. 3, and if he is not sure *which* he will not know whether his unit leader *is on his right hand or his left.* In short, Lieutenant Mahan might just as well give the order "count threes" and be done with it, and it must be perfectly plain that it will take more time to form his company than by Upton. In one case the *men* count fours; in the other case the *lieutenants* count threes. In one case the first sergeant forms the company; in the other case it requires the first sergeant and two lieutenants to do it. In one case the company is divided into *two* platoons; in the other case into *three* sections. In one case the platoons do not embarrass the deployment as skirmishers forward on the centre, but we may deploy without dividing into platoons; in the other case the division into three sections is absolutely necessary and it delays the deployment.

Treating of the battalion, Lieutenant Mahan gives a method of deploying the whole battalion in "a single line of skirmishers." The orders by this method would be as follows: By the colonel—1. "On the centre company for battle action double time march." (10 words.) By each captain when company interval is attained—(2). "On the centre section for battle action double time march." (10 words.) By each captain and each lieutenant after sections get their intervals—(3). "On the centre group for battle action double time march." (10 words.) And finally each captain commands "deploy," making 31 words. As before, the third set of orders, being given by three separate officers of each company, ought really to be counted three times, which would make 51 words. By Upton the commands are, by the colonel—"As skirmishers on left four (such) company take intervals double time march." (12 words.) Each captain when company interval is attained—"As skirmishers on left (or right) four take intervals double time march," (11 words), and finally each

captain "deploy," making 26 words in all, compared with 31, or 51, by Lieutenant Mahan's method. The principle of the deployment is the same, except that the unnecessary deployment of the sections of each company by Lieutenant Mahan's method requires more time and causes an unnecessary repetition of orders. As in the case of the company, therefore, Upton's deployment of a battalion would be quicker and simpler than Lieutenant Mahan's, and we have another change for the worse, with new orders for an old manœuvre.

It is certain that in no modern system will a battalion, operating alone, ever be deployed in a single line of skirmishers, but always in three lines—a firing line, a supporting line, and a reserve. It is even a question as to whether the battalions in the regiment should not each form its own firing, supporting, and reserve line, thus preventing the mixing up of battalions as far as possible. This is a matter for discussion, however.

Lieutenant Mahan deploys the battalion into three lines from column of companies, and gives a method of manœuvring in action. In this disposition of the battalion all three companies are deployed, even the reserve, and in three lines "separated by from 10 to 20 paces." It is evident that these three lines are so close together that they are all subjected to the fire of modern weapons, while the reserve, at least, is powerless to contribute to the fire. All the men might as well be in the same line as far as protection is concerned. Lieutenant Mahan says the first two lines do the fighting by alternately rushing and passing each other. This would seem to be a dangerous expedient. A man would hardly feel happy with his friends firing in rear of him, and should he not advance in a straight line, but zig-zag to get cover, he would be as much in danger from friends in rear as from foes in front. In this attempted inter-passing of two lines in the smoke and noise of a fight it is probable that there would be much confusion and the fire of both lines would be seriously interfered with. Volley firing, which we are told must be the essence of any modern system, would hardly be possible in this case. In every modern system that I have been able to look up, the supporting line is held some distance in rear, gradually feeding men into the firing line, these men always attaching themselves to the groups of the firing line as soon as they reach it. Sometimes entire groups from the supports may be thrown into intervals that may exist. In this way the supports are gradually merged into the firing line, and the different groups, being kept intact, may advance by rushes in echelon and fire by volleys. This would be far better than having two lines alternately rushing through each other; there would be less confusion, and less danger from friends.

But it is in the matter of the reserve that Lieutenant Mahan appears to have made a fatal mistake. In the first place he *deploys* his reserve, whereas in every modern system *the reserve will be kept massed under cover until needed.* In the second place he deploys it so near the firing line (20 paces) that it cannot move by the flank to meet a turning movement; it cannot be assembled or moved to the rear, in fact it cannot be manœuvred at all except "under the terrible fire of modern weapons," in open violation of Point No. 4. In short, by this disposition of the reserve, Lieutenant Mahan throws away all chance of

properly meeting a flank attack, or of making a flank attack himself. But flank attacks, and a little strategy, are ten times more necessary now than ever before, and men will take more delight in making them than in attacking in front. Lord Wolseley says: "In future, owing to the long range of all arms, attacks upon the centre must be very exceptional; *the flanks will be the points to aim at.*" Now suppose Lieutenant Mahan's opponent throws his supports into his firing line, which gives him as many rifles as Lieutenant Mahan has engaged, and then, keeping up a hot fire, sends a portion of his reserve to make a detour and take Lieutenant Mahan in the flank, what will be the result? If Lieutenant Mahan's reserves get up on their feet most of them will be obliged to run the gauntlet along the whole line of fire, and few would probably arrive to meet the attack. *The side which most surely retains the means of meeting or making flank attacks will be most apt to win.* In this treatment of the three lines for a battalion, Lieutenant Mahan is hardly justified in quoting as his authority Sir Lumley Graham's principle: "The formation of infantry for battle must be such as to *favor* to the utmost the effect of its own fire, and to *minimize* the damage done by the enemy." It would seem, on the contrary, that three lines so deployed would *minimize* "to the utmost the effect of their own fire," and *favor* "the damage done by the enemy."

Lieutenant Mahan's propositions to do away with a fixed front rank and to use "to the rear" and "about face" instead of the wheel about by groups, are all most excellent. Time would always be saved by such changes, and officers would not feel a pang (as all are apt to do now) whenever they get their fours inverted. The method of deployment to the rear is new and certainly a most excellent change. It might be very necessary to deploy suddenly and take up a position in rear of the company or battalion. At the order "to the rear," or "about face," the guides could step back and allow file closers to pass through and take position in rear. All these changes should be recognized as gaining time and conducing to mobility and freedom of movement.

To sum up:

1. The reason, or necessity, for changing from units of four and groups of eight to units of three and groups of six should be carefully considered, that the rule of multiplying and dividing everything by three may not result in loss of flexibility.

2. Up to and including the battalion, it is not plain that Lieutenant Mahan's methods are always founded firmly upon the excellent *points* and authorities he cites, but that many of these points and authorities may be turned against his tactics.

3. With deployments similar in principle, but often less simple than Upton's, we have an entirely new system of orders—mere changes in words.

4. In the one most essential feature of modern tactics, the deployment and manœuvring of a battalion in three lines, we find that Lieutenant Mahan's methods fail entirely to meet modern requirements and violate his own points. In this respect, the most important of all, his plan is not so good nor so modern as the plan provided for in Art. 354, Upton's Tactics, where one half the battalion is deployed in the firing line, about one third in the supporting line 300

yards in rear, and the remainder held in reserve 400 yards in rear of the supports. Upton here agrees very nearly with Lord Wolseley's rule of one half, one third, and one sixth for the three lines.

These criticisms and opinions are submitted with all due humility, with no disposition to resist well considered changes, and with the firm belief that the board of army officers now sitting will solve successfully the problem of a modern system and give us one that will be flexible and equal to all demands. We certainly should not fall down and worship Upton with the blind, innocent faith with which a Chinaman worships his little wooden god, nor should we be too ready to reject one god for another of the same or worse material but covered with different war paint.

As regards cavalry attacks, Lord Wolseley says: "The formation of battalion squares to resist cavalry may be almost regarded as a thing of the past, for with long-ranging arms of the day, to put your battalion into such a formation would be to give it over to destruction. *Small company squares* or *groups of men* standing together shoulder to shoulder and availing themselves of any hedges, trees, or any other obstacle there may be at hand, *can now hold their own well against any number of cavalry, and very rarely will cavalry be found to charge infantry in line who are armed with the murderous breech-loader.*"

It appears that Lord Wolseley prefers *small* company groups or squares to any other formation, and inclines to the belief that no other special formation is necessary to resist cavalry. The quickest formation would seem to be the best—*the one that will least disturb the particular formation in which the infantry happens to be when attacked.* But Lieutenant Mahan, doing away with company squares or the resistance by groups, which would be quick and effective (according to Lord Wolseley), gives us a long and rather intricate manœuvre which would make it appear that cavalry attacks are very dangerous. With a battalion Lieutenant Mahan forms "echelon of companies and deploys one section of each company as skirmishers," and with the brigade he "forms line of battle with centre battalion, deploys centre company thereof, forms right and left battalions in echelon of companies on respective flanks." In other words, we have both a skirmish line and an echelon formation to resist cavalry. One or the other is certainly unnecessary, and to do both is uselessly to consume time. If skirmishers cannot resist cavalry *alone* they should not be thrown out at all. If they *can resist it* they should be supported instead of wasting time with other manœuvres. Lieutenant Mahan says "the battalions are so situated that every rifle can be used against the approaching cavalry." Can they use their rifles with a skirmish line in their front? Certainly not until the skirmish line is withdrawn or destroyed. Does not the skirmish line thoroughly protect the cavalry from the fire of the battalions? Not only this, *but Lieutenant Mahan cannot use his artillery at all against the cavalry* because of his skirmish line. I cannot see that Lieutenant Mahan improves matters by this method, or secures the "simplification of formations" of Point No. 1. Throwing out a weak and insufficient skirmish line (one company in a brigade), preventing the use of artillery or infantry, is not in accordance with Sir Lumley Graham's advice "to favor to the utmost the effect of our own fire and to minimize the damage done by the enemy."

Instead of these devices to resist cavalry it is probable that simpler ones may be used. If the battalion or brigade is already deployed in proper battle formation—three lines, the supports thrown in to the firing line and rallied by groups firing volleys will meet the attack in front. Our own cavalry and our reserves of infantry and artillery may be used to meet flank attacks—that is what they are for. Surely we cannot change front with our whole force of infantry, or form echelon of companies or battalions if the enemy has infantry at hand, and any good method must suppose the worst—that the enemy has something besides cavalry.

Should infantry not be deployed when the attack comes, but if it is in line, column, or any other formation, send out a sufficient number of companies to meet the attack, or receive it as we stand with volleys from infantry and artillery and send our cavalry to attack in flank. According to Lord Wolseley this will be sufficient, and will prevent a loss of time. If artillery is at hand it might be well to invite cavalry to attack us in order to destroy the enemy's force. Infantry should not be taught, with their present weapons, to *fear cavalry*, by the adoption of such means to resist it; rather impress them with the idea that they are always more than a match for cavalry in whatever formation they may chance to be. If all this manœuvring is necessary to resist *threatened* attacks of cavalry, our enemy could stop our progress completely and keep us everlastingly changing front and forming echelon of companies, by threatening first one flank and then the other, and we would never succeed in getting anywhere.

Lieutenant D. H. MAHAN.—My reason for changing the unit from two or four to three is, that I think four sometimes too large and two too small for a column. Take a country road for instance, such as an army has often to march along; I consider three as a preferable number.

In regard to the danger of this plan having a single idea pervading it, may it not be asked if the single idea does not pervade Upton; that is, his idea of counting off by fours? How could one drill by Upton if it were not for his idea of four which pervades it? His system of fours does not hold throughout, but might it not be better if it did? How many plans does one now have to remember? Lack of space obliged me to leave out many explanations of my plan, and many cuts could not be printed by the Institute which would have shown that it was not so dangerous and narrow as it is supposed to be. In regard to having four companies, I can employ a fourth company with machine guns; this, however, will not interfere with the formation.

On board the Boston, why might not the companies be composed each of two divisions; this would not necessitate a call for men from the powder or navigator's divisions. Combine the first and third divisions—67 men—send five of these to complete the company composed of the second and fourth divisions, and there would be two companies of 62 men each. With a captain and two lieutenants each, the two companies would be better officered and the organization require fewer officers. (There should be two officers to a company of 36 men.) The Boston's companies then should have, under the present organization, eight officers in all; using my system, only six are required. It may be

asked where my third company is to come from. Form the marines in single rank, the sergeants taking the places of the lieutenants; there would be 35 men in all. Again, a front of nine men is none too small for street fighting, and in marching in column of sections there is a complete organization at the head of the column, which can be drilled as a company. The front can be increased to 18 men by obliquing the rear rank to right or left. I think that the assertion that "if the company were composed of 63 men the divisions would be quite broken up" is not verified by my showing above.

I use the word section because a platoon is supposed to be one half of a company; my section is but a section of a company. In the next paragraph complaint is made about orders being too long; here they are considered too short—some people are never satisfied. Again, in quoting orders they should be quoted correctly: the order is "To the right flank march," and not "Right flank march."

In comparing my orders with Upton's, Mr. Fullam should have been generous enough to have also taken one of my short orders, "Deploy," by which I can deploy a company with one word as quickly as Upton can, using twelve words. Counting words in orders is, however, a good deal like splitting straws. Orders are necessary to have work performed; during drill they are used in their entirety, on the field of battle but seldom. Recalling two famous orders used on the field of battle which never appeared in a tactical book, will show how unnecessary any discussion about orders is. "A little more grape, Captain Bragg," was longer, but accomplished the same result as completely as if the order "Load with grape" had been given. "Up, Guards, and at them!" did a thousand times more good than "Rise, charge bayonets, forward, double time, march" would ever do. As far as making one learn a new language is concerned, did not Upton's cause such a change?

In regard to the repetition of orders Mr. Fullam seems to lose sight of the fact that after the company has been deployed in line of sections, I might wish to deploy only one section on account of the nature of the ground over which the company was advancing. This is the time when the lieutenant gives the orders. There is nothing to prevent the captain giving the order for the whole company, but I have provided for the case in which the country might be such that the captain could not possibly see all his command.

Deployments will always be essentially the same in any tactics that may be written, and I fail to see how it is made more difficult by introducing an intermediate step between the company and the group. If Mr. Fullam had read my article carefully he would have seen the object of my developments in Plate V., but, since he wishes to arrive at mathematical precision as to distance travelled, let us take these two cases—a front rank of a group of threes and a front rank of a set of fours: the former deploys on the leader (centre man); the latter on No. 4. Deploy five paces to the front each squad; with mine the men walk 7, 5 and 7, with Upton's 5, 10, 15, 20: $20 - 7 = 13$, a gain for my system of 13 paces, or in other words, deploy both and my men will be each one 13 paces in advance of Upton's. Take now the group of three and the set of fours; the paces are 22 and 25, or I have deployed and advanced three

paces when the others have finished deploying. (This is explained in answer to Mr. Haeseler). Now for the company. I deploy on the centre group of the centre section, the other on the right or left set of fours. (I leave my section development out, as it can be used or not.) I will take my complete company of 54 men, allowing only 48 men to the other. When the latter has deployed, I will have deployed and advanced 70 paces. Now I will deploy the smaller company on the centre skirmisher and my own company ; the smaller company will have the advantage of mine by two paces, but increase the smaller company to the same number of men as mine and I will be ahead by 6 paces. The distances have been computed by taking the distances marched by flank skirmishers of each set of men. Credit is not given to the fact that the company can be deployed at once to the group line ; it is also forgotten that in a fan opened from the middle the two outer sticks have just one half the distance to go as if it was opened on either outer stick. Not intending to write a tactics, each and every movement that can be made has not been given.

"To provide for a special deployment in case of surprise is to acknowledge the weakness of the ordinary method"; this is a new way of looking at it. It might as well be said, if our present tactics show no deployment in case of surprise, of what use to think of it? I have heard of ambuscades, of surprises, of how men have been shot down as they stood, not having been drilled as to what to do in such a case. Would it not have been well to have had some drill for just such an occasion? It is by this repeated drill that I desire to have my men so trained as to be in no danger of a surprise discomposing them. If they know just what to do when the captain yells "Deploy," are they not better prepared than if habituated to await a longer order, having been drilled to deploy by numbers and also by fours, but no way given in case of surprise? Better to have a little scramble (for shelter), out of which order will come, than to stand huddled like a flock of sheep waiting for some officer to decide which to use, numbers or fours, and, unable to stand the attack, rushing to the rear with no leader and no idea what to do. Mr. Fullam fails to see that my "artificial combination," as he calls it, is only my regular deployment with deployment to sections left out. He says that only by repetition hundreds and thousands of times can these things be learned, yet he says a few lines below, "even if the units keep together (which is doubtful under such instructions)"; or he praises and condemns in the same breath.

Mr. Fullam may say it is a "fatal mistake to teach men to *seek shelter* until after the deployment is complete," but that same teaching has saved many valuable lives in Indian campaigns, and I would rather have my men make the "fatal mistake" and live, than have them stand in military precision to be shot to death waiting for the development to be completed.

How far did Mr. Fullam deploy his company, and how can he make such an assertion as he does, until he has seen some movement tried? Having shown my forward deployments, in which I think I have the advantage over Upton, I will now deploy two companies of 54 men each. If deployed to the left flank I gain 5 paces on the other, for deploying on the centre man of that group one man goes to the right; if deployed to the right flank, on the centre man of

the group I gain 20 paces, as four of my men go to the left flank ; if deployed on the centre skirmisher I gain 30 paces, for 28 men go to the left and 25 men to the right; in the other, 34 go to the left and 19 to the right. So while Mr. Fullam has deployed his company I have deployed and advanced my whole line 30 paces.

In Upton there is no leadership in the group and there is no development of comradeship. My surprise development having the centre man as leader, *preserves* instead of *preventing* what I have said in No. 6 ; and although it may cause orderly dispersion before the conflict, it may save disintegration during the conflict.

Mr. Fullam proposes either to develop his skirmish line two miles or thereabouts from the enemy, or to march his full battalion up to close range. I desire to gradually diminish the size of my target (making the direction and speed of movements somewhat irregular, as required by the Austrian field book), at the same time continuing my system throughout. In the former you go from the "plank of the line or the log of the column" to the individual, while I try to do it gradually and preserve my "comradeship in groups" with "a thorough command throughout."

Had Mr. Fullam read carefully he would have seen that *in no case* do I allow a rank to pass through another, nor does he notice the words necessary in his reference to "even the reserve." Not always do I deploy my reserve, only if necessity calls for it. I can always keep my reserve of one or two sections or companies (as we refer to companies or battalions). I can use either section or group as a reserve, while Upton uses fours from the right or left. Having the centre as reserve, I am in nearer supporting distance to either flank.

To show that there is no interpassing of ranks, I will quote a few of my own words: "The advances when the company is deployed will be by rushes of sections. The centre rushes first, covered by the fire of the right and left sections, followed by both the right and left, or, if the opposing fire is very heavy, by only one section at a time." But the first line is always the first; the second, the second ; the third, the third ; until "such time when the first can no longer advance unaided." I follow out in this what Sir Lumley Graham says, "the firing line has to fight out the battle through all its stages to the very conclusion, being supported in doing so by the troops in close order." I feel also that I am justified in quoting Sir Lumley Graham, as my advance would not *minimize* their own fire and would not favor the enemy's damage nearly so much as the present system of advance in the skirmish line, in which there is a continual interpassing; Nos. 1 and 3 firing as Nos. 2 and 4 advance and *vice versa.*

In the summing up I would like to say, (1) that the system I have presented has been carefully thought out, that it is not, as Mr. Fullam thinks, but little considered. The plan was conceived several years ago, and was only finally presented when I saw no one else seemed to take sufficient interest in the subject, and so I thought I would start the ball rolling. In marching in column of fours I have many times observed that the file closers have to press into the column, and in the usual but preposterous march round, the column

of threes would work much better in the narrow gangways. I think that my system, if experimented with, would develop an increase of flexibility instead of a loss. (2) My method, I think, more nearly approaches the points I have selected as my guides, than any we have in use, and although my points may be turned against it, they have not done it any harm. Upton himself recognized the fact that his tactics were not such as they should be, and at the time of his death was revising them. (3) I have discussed before. (4) Mr. Fullam has not considered No. 3 of my points, in which I have desired "a general principle for advancing into action, which would apply to all bodies of men, *large or small*, so as to maintain cohesion from the highest officer down to the single private." I think I have met the modern requirements in my plan, although I may not deploy my men quite as Mr. Fullam would desire. I achieve the same result of getting my men into the firing line, while I keep them under a system of command all the time. I have a "direct movement," while I can manœuvre my men if necessary, and my men are more "free to push forward, as required, according to the ground." Distances can always be changed at will, and have to be left to the commanding officer. I do not violate my own points, but Mr. Fullam has in many cases read between the lines without seeing what was above or below. My plan of three still exists; I give one third to each line because I think the distribution to the different lines will have to be changed as the machine and repeating arms come into more general use.

In regard to the defenses against cavalry, Mr. Fullam puts words into my mouth that I did not know were there. I do not intend to rally my companies so as to form an echelon of companies, for I have said "that the day of rallying by companies is, I think, over." I had my brigade standing in column of companies, threatened by an attack, and this is the formation I would prefer, as it is easy to make. If my men were deployed in sections or groups I would receive my attack in them. Artillery does not generally accompany infantry, but is employed on commanding eminences; cavalry will seldom charge up hill; infantry acting as a support for artillery will therefore be comparatively safe from calvary. If a strong skirmish line can be thrown out, the cavalry will hesitate a moment before charging in between two fires; if they attempt to sweep out the skirmish line, the main body will most likely decimate them. I am sorry that Mr. Fullam regards my formation and subsequent movements "long and rather intricate," when they consist of, in one case, a "forward march" of three companies and a "right half wheel" for six; for the other case, an "about face" and "left half wheel" for three, followed by an advance and the same "right half wheel" for six. Since this is a long and intricate manœuvre, it may account for Mr. Fullam not getting a good idea of my paper, in which some of the points are rather more intricate.

Ensign F. J. HAESELER, U. S. N.*—There is no doubt but that our tactics need modification and adjustment to suit the magazine rifle and the more rapid movements required in the manœuvres of the present day, but at the same

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time, if such modification or change is to be made, it should be of such a character, if possible, as either to cause little or no confusion in the existing formations, or such that the complete organization and system be entirely renewed.

It is evident that if the former can be done it will be much the better, and to that end any change that will tend to cause confusion, by having the proposed manœuvre similar to the one in use and yet different in the minor details, such as orders, etc., should be discouraged. If the present system of Upton's were not in use and I were asked my opinion of Lieutenant Mahan's paper, I should say that it was a most excellent idea; but as it is, I wish to call attention, briefly, to the similarity—in fact, sameness of the method proposed and the one now in use, and further, that where there is any minor difference it is in favor of Upton's.

Before doing so, let me show that the present organization adapts itself to the particular points quoted by Lieutenant Mahan:

"1st. A simplification of the formations, giving the utmost freedom of movement, and developing an individual order."

Our formation is based on a unit of four. This unit can be handled by itself, with one, two, or any number of similar units, and can be subdivided into half units, and further, into individuals. It further admits of changing the unit of four into one which, while acting as a unit of four, contains eight men, very aptly called groups by Lieutenant Mahan, which is similarly capable of being massed with other groups or units, or of being subdivided into individuals. This is likewise done in the system suggested, with the exceptions that three is used as the unit, and further, that the unit cannot be subdivided into half units, which is sometimes convenient.

"6th. In addition, a thorough command, a development of comradeship in small groups, giving rallying power to small parties."

This is likewise attained by the Upton system, as the march in groups (fours) and the deployment and rallying by fours give the results desired.

Lieutenant Mahan begins with the individuals and drills them at setting up drills, the facings, etc.; he then drills them as units, then as groups, then sections, companies, and finally battalion or brigade. In the present day we do the same thing, with the exception of having four as our unit instead of three.

In the proposed organization the men have no numbers to remember; they are simply men, standing as regards certain centre men, and, as the author seems to make a point of this, let me call attention to the fact that they *must remember* what position is occupied by them. No. 1 must not remember that he is No. 1, but he must remember that he is on the right of the centre man,—or, if the men are so drilled that they will always have the same positions, and will rally always by instinct in a certain direction, and should happen to be faced to the rear, what would result? No, I doubt very much the efficiency of not having the men required to have numbers. In the present system the front rank men, with the exception of one in every four who stands fast, deploy and rally *in the same direction*, while in the proposed scheme one third stand fast, one third rally in one direction, and the remainder in the other. Again, when in company, in case of assembling during battle, if one of the men on the right

of the company were missing, all the rest would be out of their regular places, and then our original No. 1 has to remember that now he is on the left of the centre man and rallies to the right, instead of being on the right of the centre man and rallying to the left. Would it not be much better to stick to the present system even if three should be adopted as the tactical unit and count off? How much easier for instructors and recruits it would be to say that No. 1 obliques to the right and front, No. 2 proceeds directly to the front, and No. 3 obliques to the left and front in the deploy, than to go into such general terms as the centre man, the man on the right of the centre man, and the man on the left of the centre man. No better illustration of how simple the number system is can be had than that Lieutenant Mahan uses the numbers 1, 2, and 3 in his explanations, saying that No. 2 is always the centre man, etc.

The units and groups being the same as those in present use, we pass to the sections, which comprise three groups each, and that is simply the same as though our platoons were limited to a certain number of fours, which they could be if deemed advisable. Here let me call attention to a violation of the first point quoted by Lieutenant Mahan. If a section marches in column of groups, the distance between the breast of one man and the back of the man in front of him will be only 21 inches (in column of fours it is 32 inches), and, as the length of the direct step is 30 inches, it will necessitate what is commonly known as lock step marching, which is very tiresome to the men.

The modification, then, in the organization comes in the company, which is divided into three platoons or sections; the first lieutenant being in charge of the right section, the second lieutenant in charge of the left section, and *no one in particular* in charge of the centre section. This organization gives a company front of 108 men on the skirmish line in time of war, which, with intervals of five yards, would make it extend over 540 yards, about one third of a mile, which would be rather a white elephant on the hands of a captain with two officers, even provided neither of them were shot down early in the engagement. They may have to be assembled and transferred suddenly somewhere else; the survivors come together, the middle men are no longer middle men, and the first lieutenant happens to be shot down and some one else must count them off, both of which incidents (they can hardly be called accidents) will cause delays—while the assembly, according to the present tactics, will admit of counting fours and marching off at once whether the first lieutenant or any lieutenant or file-closer is there, and in addition, a company can count fours in less time than an officer can divide off into groups of three files each.

The manœuvres of the units in the different marchings by the flanks and to the rear are the same as at present used, as is also the deployment of the group, with the exception that it is made on No. 2 instead of No. 4. This is an error, since it will take one quarter longer time than necessary to deploy a group of men, or, in other words, deploying a group on No. 2 front rank will take the same time as deploying a complete four (eight men) on No. 4 front rank, inasmuch as No. 3 of the rear rank of the group will have 20 yards to go to the left; hence the inadvisability of using No. 2 as the centre man is apparent.

This being the only difference in the deployment of the group from that of Upton, it would hardly do to make such a change in our tactics.

The sections are drilled in the same manner as the platoons or companies are at the present day, and all the manœuvres and deployments, made according to the proposed drill, can be and are executed according to Upton's tactics. In the battalion the only difference discernible is that after the battalion has deployed into companies, with intervals, as is done by Upton (Art. 332, page 135), the companies are subdivided into sections before deploying into groups. In my opinion this is an error, as it necessitates half of each section except the centre section going twice over the same ground.

The deployment from column of groups forward into skirmish line is an excellent one, and could be done according to Upton's tactics if it were authorized by the Adjutant-General, as it is a perfectly similar manœuvre to "In single rank, left front into line," and could be so executed, substituting the words "In skirmish line (so many yards interval)" for "In single rank." The deployments to the rear can be executed by wheeling the battalion about by fours, which will take but little more time than the about face, as the file-closers, lieutenants, and others, would have to be ordered to the rear before the deployment was made. In addition to the fact that all the manœuvres prescribed in the above paper can be and have been done according to Upton, the deployment forward, or to the rear, by the numbers is *not possible*, as the men *have no numbers*. This formation of the skirmish line I consider as being, if not the most important, one of the most important, as then the number of officers per yard front of fighting line is very much increased, and no company is disproportionally weakened by any particularly heavy loss on the skirmish line. In addition to that, as one, two, three, or more lines can be formed without any intricate manœuvring, and the necessity of having skirmishers thrown out in such a formation that they can be quickly relieved or assisted seems to be a well recognized matter, it would seem to be of too much value to be neglected.

There is another point in which I must differ from Lieutenant Mahan, and that is in his method of rallying. Rallying, when deemed advisable, has a two-fold object, to cause demoralization in the enemy's ranks, and to have a formation that will protect, by the bayonet, from the sabre of the cavalry. It has the disadvantages that the target presented by the group to the revolver of the cavalry-man is much larger, and the chances of some one of the group being hit very much greater than when deployed, and also that valuable time is lost in the rallying and deploying, during which the body is more exposed. Lieutenant Mahan suggests that the rally shall be used, and that as soon as *one volley* is fired the group or unit deploys. Of what use is a magazine gun if it is not to be used on such an occasion, and what demoralization would a volley of three or six rifle shots, even if fired together, carry into a body of cavalrymen when on a charge? If men must rally, let them fire as rapidly as possible in volleys, and as long as possible, and if they can thus turn a charge it will be time enough to think of deploying. I do not pose for a tactician, but I do think that the open order formation, the men being armed with magazine rifles, will stop any ordinary cavalry charge.

It has occurred to me that, judging from the manner in which the different evolutions are performed, Mr. Mahan has intended to follow Upton as closely

as possible, and with that view has made the evolutions the same. We then would have the question reduced to whether there are any such glaring defects in the system that has four as a unit as to make it necessary to adopt some other number, and further, whether the adoption of three as a unit would obviate those defects. This change would cause a vast amount of confusion in the service, and furthermore, would differ from the Army, and as far as I can see would be of no benefit or tend in any way to increase our efficiency as a military organization.

The artillery at present conforms to the infantry, the battalion being divided into any number, usually four, of batteries, the batteries into two platoons, and the platoons into two sections.

If it were desired to carry the comparison of the unit to the fleet, we have four divisions, the van, centre, rear, and reserve divisions ; but why skirmish drill should be connected in any way with the manœuvring of ships I fail to see.

Lieutenant D. H. MAHAN.—In all tactics there is a general sameness, but I am not so sure that the odds are all in favor of Upton and against mine, as Mr. Haeseler says. I have not held that Upton's did not possess some of the requirements of my first point ; but let me call Mr. Haeseler's attention to one point of which Mr. Fullam complained in his discussion, "the wheel about by fours." On one occasion I saw a battalion so mixed up, by a wheel about and two or three subsequent orders, that it was considered best to break ranks and reform the companies. (During this part of the manœuvre point No. 1 was fully carried out.) This may be simple, but I fail to realize it. By my system the men face about and manœuvre in exactly the same way as before ; besides, it makes no difference to me where my men may stand as long as there are three left to drill, consequently there is no chance for such confusion as I have quoted.

Again, in developing my section (or company) I can deploy all my front rank —or a part of it—and my system still continues. Upton deploys Nos. 1 of the front rank and his system of fours (claimed by Mr. Haeseler as existing throughout) is broken up. My deployment can be assembled in small groups, no matter how they deploy. Let Upton deploy Nos. 1 and 3 and desire to rally them in small groups, can you do so ? No ; you have to rally either on the right or left skirmishers, for there is no designated centre skirmisher, and in making this rally the men have to traverse a good distance of country, from one end of the line to the other, and then present a large target to the enemy, with several of the men well tired out after a spin of from 80 to 115 yards. There is the utmost freedom of movement in this also.

Mr. Haeseler quotes my 6th point in favor of Upton; but after fours have been deployed, who looks out for the set of fours in case the lieutenant and non-commissioned officers have been disabled ? What comradeship is developed when you deliberately break it up by deploying by the numbers ? There is none, and, being deployed by numbers, there is no rallying power to small parties. In my system there is command throughout, no matter how you deplete the company, group or section. Until there are but two left, the system and command is complete throughout. There is always rallying power

in small groups, since my system of threes is never broken up, although Upton's system of four, which Mr. Haeseler says prevails throughout, does not in this instance.

There is no necessity for dividing my unit into halves, as I cannot see where two men could be of more use than three, and the odd man might decide. I do not believe in having numbers if it can possibly be avoided, and had I been writing a tactics no numbers would have been used. It is usual to make explanations as simple as possible in an address delivered before a society; the members of the Institute having been accustomed to using numbers, it made the subject more easily understood than if I used right, left, and centre, as I have done in the remainder.

It is very easy to compare my divisions of companies with Upton's, but the words "as though" say a great deal, nearly as much as "if." Again, in reference to the lock step so dreaded by Mr. Haeseler, he forgets that "route step" is the general gait on the march; distances are not kept intact. On the battle field no step taken by one man will interfere with any one in front of him. The cadets here march in column of twos with a very quick step and do not seem to feel it tiresome.

Quoting Mr. Haeseler's words italicized, "no one in particular." Again Mr. Haeseler has not read my paper carefully, or wilfully ignores it. If he had read carefully and remembered other parts besides what his attention was on for the moment, he would have noticed in the section deployment these words: "the lieutenant in charge of *section,* while commanding all, looks out *principally* for the *centre group.*" He must have known that by my system it is necessary only to interpolate words (always increasing one step) to suit all cases, as: "the *captain* in charge of *company,* while commanding all, looks out *principally* for the *centre section.*" He must have seen, but failed to grasp, many points in my address, as further on I say, "the captain and lieutenants . . . . over the sections."

Knowing that a company extended would be rather a white elephant, by my system I have resolved Mr. Haeseler's white elephant into three intelligent but smaller animals, easily guided by a lieutenant, which is something Mr. Haeseler does not do; he prefers to bind in his elephant's trunk and tail and to hunch up his back, or in other words, he prefers to keep his men closer together and in more ranks, presenting a better target to the enemy simply so that the captain can have entire control. Is this developing a thorough command throughout even to small parties? And then the idea of assembling and counting off by fours on the battlefield!

I have shown in my discussion of Lieutenant Fullam's paper that I have gained 13 paces per man in the advance of the front unit of three, as against the front rank of fours. Let us now consider what Mr. Haeseler says on the subject of both ranks. The movements of each man by paces are about as follows:

Upton.		*By threes.*	
No. 1 front rank,	20 paces.	Right front rank,	7 paces.
No. 2 " "	15 "	Centre " "	5 "
No. 3 " "	10 "	Left. " "	7 "

Upton.				*By threes.*			
No. 4 front rank,		5 paces.		Right rear rank,		22 paces.	
No. 1 rear rank,		10	"	Centre	" "	20	"
No. 2	" "	15	"	Left	" "	22	"
No. 3	" "	20	"				
No. 4	" "	25	"				

or three paces in favor of my system. So that I can move my men each three more paces forward by the time Mr. Haeseler has finished his deployment, consequently, all things being equal, my men will be three paces nearer the enemy than Mr. Haeseler's men. He does not mention the fact that Upton, in his deployment in groups, marches over a certain amount of ground, then, when they deploy, three men in every set of fours (except the one moving forward) have to retrace their steps ; that is almost one half of the whole instead of half of two-thirds as in mine. Also my deployment can be without this ; and if I deploy at once by groups, my gain as to paces increases over Mr. Haeseler's. To go a step further in the mathematical line for the benefit of both Mr. Haeseler and Lieutenant Fullam : after deploying as above, let the two rally, mine on the centre front rank leader, Mr. Haeseler's on No. 4 front rank. The distances for my men will be $5+5+10+15+20$ paces, equal to 55 paces ; for Mr. Haeseler's men, $5+10+15$ and $5+10+15+20$ paces, equal to 80 paces. Now deploy ; Mr. Haeseler's men have moved 160 paces and my men only 110 paces, a clear gain of 50 paces of work.

It is not my intention to have my file closers pass through the ranks ; it is unnecessary with carefully drilled troops, as the march is never long to the rear. If necessary they can be ordered to the rear, passing through at sergeants' positions.

As to the formation of the skirmish line by numbers, I do not like it, as I have said before, on account of there being no essence of command nor comradeship. Mr. Haeseler seems to think that a large number of officers is necessary on the skirmish line. Never more than one officer to 18 or 36 men is necessary, and that is my allowance. Mr. Haeseler also forgets that I can throw out three lines from one company if necessary, and these will each cover a space varying from 90 to 180 paces, with any desired distance between lines, and in each of my lines my system is complete, while the system of fours ceases to exist. I am sorry to see Mr. Haeseler put himself in opposition to such an authority as Sir Lumley Graham, who says, "The firing line [skirmish line according to Mr. Haeseler] has to fight out the battle through all its stages to the very conclusion." And again, as one of the general principles universally accepted by three of the great continental powers, I will quote (7) : "A tactical body once thrown into a firing line on the offensive, *cannot* be relieved ; its remnants, great or small, *will remain* in the firing line to the end of the action." There is nothing said about relieving here, but just the opposite, and the work from which these words are quoted is an analysis of the tactics employed by the German, French, and Austrian armies. This is his conclusion, after a careful study of the tactics of three great nations, expressed for the benefit of a fourth great nation ; whence, then, does this "well recognized" matter come ?

How Mr. Haeseler can say that my rally, when I do allow it, will present a larger target than the rally by fours, I cannot understand. By my rally three or six men come together; in his rally, eight men, or, to say the least, four. In fact, all my thoughts have been against the rally. I say the rally *might* be made, not *shall*, as Mr. Haeseler makes me say; and I even quote, "good infantry need not fear the attack of cavalry, even if in open order," so Mr. Haeseler again misquotes me by speaking of the rallies to which he refers as though I intended them against cavalry. I say, "if it is desired to concentrate fire on any one *spot*," and I also say to deploy on delivering their volley, "unless under cover." It would be suicidal to keep men together under the fire of such a gun as the Maxim, but it might be necessary, for a moment, to concentrate the fire on some one of the enemy's guns. I also quote, "Good infantry need not fear the attack of cavalry, even if in extended order. As a general rule they should be able to maintain the formation in which they happen to be when threatened. To do otherwise would only be to play the enemy's game." And again, "There is one evolution that should *not* be attempted . . . . . rallying by companies to resist cavalry." So how Mr. Haeseler worked in his cavalry I do not know. Mr. Haeseler judges wrongly when he thinks my intention has been to follow Upton as closely as possible. My deployments are different from Upton's, while I can deploy as Upton does, except as to numbers, and as I have shown, more quickly. I have my company differently divided from Upton, but I can drill it the same as Upton drills a company. His plea that this change would cause confusion is not a good one, as that confusion is bound to come if we would *not* differ from the army, as a change in our tactics is coming.

That Mr. Haeseler may fail to see how skirmish drill is in any way connected with ships I can readily understand, as nothing is said in reference thereto, but this is only one more instance of misquoting.

Lieutenant L. W. V. Kennon, Sixth Infantry, U. S. A.—In submitting the following remarks by way of discussion of Lieutenant Mahan's system, I shall confine myself simply to its application to the infantry arm of the service.

In developing his ingenious system of drill he has evidently been governed to a great extent by the principles enunciated in Colonel Macdonald's lecture. In these principles he has found a statement of the conditions to be fulfilled in any effective system of infantry drill adapted to "modern requirements." He has attempted to develop a system which shall fulfill these conditions, and that he has succeeded in doing so cannot be questioned. The importance of closely scrutinizing these conditions, the foundation upon which his system is built, is therefore manifest.

Colonel Macdonald objects to the "present style of drill" because it is not applicable to the fighting of battles under existing conditions, and proposes an "interval order," in which men can be drilled "to as great steadiness and accuracy of movement as they ever have been brought in close files. Troops," he continues, "should be trained to move as accurately, as strictly, and as firmly in discipline in open order as they now do in close files. The hard

and fast line which now separates the parade drill from the practical exercise should be removed, and rapid and frequent change from one to the other should be a distinct feature of the training."

The use of the words "open," "extended," "interval," or "dispersed," as applied to an order of battle, is believed to be entirely misleading, and to express a complete misconception of the character of the fighting line of infantry troops on the field of battle. The idea that such troops when engaged in battle must form a line of skirmishers in the "interval order," is one which at this day is confined to those nations only which have had no recent war experience. It is an idea which has taken deep root in this country, where a faulty and inadequate system of drill has fostered and conserved it. General Upton fully appreciated this fact, and realized that the weakness of his system lay in its battle formations.

His tactics evidently presumes an attack in a double rank "line of battle"; skirmishers were to be employed "to clear the way for the main body," "to annoy the enemy and exhaust his fire before the main attack, or to pursue him promptly after a repulse." It is prescribed that "every company of skirmishers has a *small reserve*, whose duty is to fill vacant places and to furnish the line with cartridges." These objects would perhaps be attained by a skirmish line with the intervals of five yards which Upton places between the individuals composing it, but it was not intended, nor could it reasonably be expected, that such a line could of itself win a battle.

The Prussian tactics devised in 1847 was based on the same ideas of the uses of skirmish lines, but their system was such that it lent itself more readily to the requirements of actual service than ours, and it contained the germs of a practical system which has been developed by the experience of 1866 and 1870–1.

It was found impossible to bring troops in column or in line to a direct attack; the skirmish line alone could fire, and soon it became evident that this fire was of the utmost importance in determining the result. The fire of a line of troops in interval order was found to be insufficient to accomplish decisive results, and in order to obtain the maximum amount of fire action the skirmish line was increased in strength until it contained as many men as could be placed in it and still allow every man sufficient space in which to use his weapon. This was the only limit to the number of men placed in the skirmish line. It is not therefore an "extended," "dispersed," "interval" or "open" order line at all, but an *individual order* in which every man within certain limits had complete freedom of action.

The German authorities think that one man to every running yard of front occupied by the firing line will produce the maximum amount of fire action. The French prescribe that "when it becomes necessary to begin firing, vigorous action is required with a number of rifles sufficient to obtain an appreciable result in little time. . . A rifle must be placed wherever it can be usefully employed. . . Consequently, when on the offensive at the moment of opening fire, the men are placed with intervals of about six inches (15 centimeters) from each other." This interval, it is well to note, is exactly the same

as that between men in all formations for drill and manœuvre. In other words, the French make no provision whatever for a line of skirmishers in "open" or "extended" order.

These principles being those adopted by the nations best qualified by experience to judge in such a matter, demand consideration and respect. They are opposed absolutely to our commonly accepted ideas of "extended order fighting lines." In the systems to which reference has been made there is in fact no extension. A fighting line covers only the front occupied by the tactical unit to which it belongs, this unit being supposed to be in line and in close order. The part of the unit in rear of the fighting line reinforces the latter according to its needs, and eventually becomes absorbed in it. The reserve is not a "small one," as Upton prescribes, but is many times as strong as the fighting line. Instead of dispersion we find, on the contrary, that the use of rapid-loading arms has resulted in concentration; more men are required to occupy a position of a given extent of front than has heretofore, in modern times, been considered necessary. On the offensive the number is placed at from six to seven men; on the defensive, at from four to five per running yard of front. This practice of the most advanced European powers is unquestionably based on the soundest of theoretical considerations.

The conduct of troops on the firing line next demands some attention. Von Boguslawski has probably given us the most technically accurate description of infantry engaged in modern battles to be found in military literature. He states that the enemy was approached "by a succession of rushes. This was done either by taking advantage of cover, or else the men would advance about a hundred yards at a run, throw themselves down, and then run on again. . . This advance would occasion separate strokes and counter-strokes, which naturally caused the tide of battle to roll backward and forward. At this period the fight would attain its highest pitch of intensity. The fire of the breech-loader on both sides resounded unceasingly. . . If fresh detachments came up from the rear during a stationary musketry fight, whether to strengthen the line of fire or to make an attack, it was necessary to double these up with the old skirmishers, because closing the latter to a flank was not usually to be thought of; thus men of many different battalions and regiments were intermingled. . . If the ground was broken, the intermingling and dispersing of tactical units was uncommonly great. . . During the forward movement they (troops) dissolved themselves and ran on to join the skirmishers so as to get at the enemy as soon as possible. . . The men would rush on impetuously and would soon be driven back a bit by a counter-attack of the French." Von Boguslawski speaks of "the disorderly forward rush" of the skirmishers, and of the fight as being a "bloody melée"; of skirmishing as being "pell mell work." This competent witness shows us the reality of an infantry fight, and that confusion must inevitably result from the mode of action forced upon troops in battle, as indeed the rapid forward advance, the rushes for covered positions, the independent firing, the advance of supports, and the losses would lead us naturally to expect.

The kind of "open order" drill that Colonel Macdonald advocates would

find as little practical application on the battlefield as the close order formations he opposes so strenuously. There can be no such precision of movement in battle as he wishes to obtain. The German author I have quoted is very far from recommending any such course of preparation. He says, "Let us therefore practice skirmishing in masses composed of a perfect medley of men. . . Infantry must be accustomed to manœuvre with greater cohesion and rapidity than before. . . The strict Prussian training in close order drill must be continued." The "hard and fast line" which Colonel Macdonald says "separates the parade drill from the practical exercise" cannot be removed. On the contrary, the tendency is toward a wider separation between manœuvring and fighting drill. Tactics may be defined as the method by which troops are formed and moved to accomplish certain objects. The most obvious of these objects are the marching and the fighting of troops. Troops must march and they must fight, and tactics must provide the best means for them to accomplish these distinct ends. The marching formations must be in close order, the closer the better, provided the men can march with ease. The "rigid formations," as they are termed, must be retained for this purpose and for that of massing troops preparatory to engaging the enemy. Drill in these formations is not only advisable but necessary. The army which has proved itself best qualified for the field of battle is the one whose system of "close order" drill is the most complicated. It is not that these "balançoires de champ de manœuvre" have in themselves any application on the battlefield, but there is no doubt that they have contributed in no small degree to the facility of manœuvre which has characterized the German, and especially the Prussian armies in campaign since the time of Frederic, and to which they have owed, particularly in 1866 and in 1870–1, many of their most brilliant successes. Besides being in itself essential, there is no other method known by which troops can obtain the firmness and discipline necessary in individual order fighting so readily or so quickly as in "close order" manœuvres. Both orders find application in war, and neither should be abandoned, but both be practiced. The drill in the individual order would not, however, have any of the "strictness and accuracy" of the interval order advocated by Colonel Macdonald. It is doubtful whether an open order would ever find application in battle. Perhaps it might be adopted by a weak containing force holding a portion of the front of battle, but even in this case its use would be dangerous. It might also be used, as the skirmish line was formerly used, to develop the position and strength of the enemy. The extended order should therefore be retained in view of these possible uses, but it should not by any means be considered as a fighting order, and the limitations of its usefulness should be distinctly understood. For fighting, a stronger, more effective mode of operations is demanded. It is not believed that a system of attack by which a company of 100 men is extended in a line covering a front of over 560 or 360 paces, corresponding to intervals of five or three paces between men, offers many chances of success, for the order of dispersion is for all purposes an order of weakness.

I have dwelt on this topic at some length because of its manifest importance, because of the very general misapprehension of the modern skirmish line and

its functions, and chiefly because evidences of this misapprehension appear in Colonel Macdonald's statement of principles which have guided Lieutenant Mahan in developing his system.

I do not believe the conditions he has assumed are those which exist upon the battlefields of the present time. While his system fulfills all his assumed conditions, it does not present a tactics adapted to the practical work of fighting battles. This must be the crucial test of any such system, and it is in this respect only that Upton's is really inadequate.

The methods of deployment by fours and by threes in the two systems are identical in principle. Both are too complex, and both are believed to be impracticable. The manœuvring of the skirmish line is practically the same in both systems. Rallies are made in similar manner in both. The rallies by "fours," by "threes," or by "groups" for "unit or group volleys," are not practicable on the firing line, nor would they under any circumstances be useful.

The attempt to retain distinction between front and rear rank men on the firing line after the engagement has begun appears in both Upton and Mahan. Any such attempt, or any attempt to advance one rank while the other in rear continues firing, must be futile. The same objection holds in the case where the battalion is deployed in three lines, in which the second line opens a "heavy fire, under cover of which the first line rushes as far forward as possible." Such manœuvres are believed to be unsound in principle, impossible of execution in practice, and fatal only to the advanced rank making the forward rush.

The rallying power of a unit of three or a group of six would not seem likely to have any appreciable influence on the general results should a panic take place in a command of any considerable size.

All the advantages urged for the unit of three or of four on the firing line must disappear if this line be of the strength which it is claimed it must have, or indeed as soon as inevitable losses begin to be felt, or the line reinforced from the rear. All the valid objections urged against Upton's system may with equal force be urged against Lieutenant Mahan's. These are, principally, weakness arising from too great dispersion, the lack of adequate provision for feeding the firing line, and the use of numbers under fire.

Lieutenant Mahan has barely touched on the question of manœuvring formations, though these must continue always to be of great importance. It is not believed that the unit of three lends itself to these formations in so complete or satisfactory a manner as that of four, which has under some form or other been adopted in the manœuvre tactics of all civilized nations.

We come now to the special features of Lieutenant Mahan's system which arise from his application of the factor of three. The plan of organization has the merit of simplicity. It does not in all cases find the approval of authorities on this subject; for instance, the battalion of four companies is universally recognized as the simplest and most effective yet devised. The company of four sections is believed to be better adapted to manœuvring than one of three. The number of intermediate links in the chain of authority between the captain and his men may be considered a defect. It would seem

to be a weak point in the system that one third of the men in a company control the remainder; as file-leaders they "direct and give the word to fire" to the others. These file-leaders, it must be noted, are not selected for fitness, but become file-leaders as they happen to fall in when the company is formed—in other words, by chance.

The claim that numbers are not employed in this system cannot be sustained. "Counting off" is not "done away with" at all. It is simply transferred from the privates to the lieutenants, who "count one, two, three; one, two, three; one, two, three. No. 2 is always centre man." Each man must remember his number in his particular set of three; otherwise manœuvring is not possible. No essential manœuvre is provided for in this system which cannot be accomplished by units of four as well as by units of three. There would even seem to be some advantages possessed by the unit of four not possessed by the unit of three.

To sum up, the geometrical progression organization possesses only the advantage of a theoretical simplicity over many others. A tactics based upon this organization would present no features of superiority over others in which the ratio of three did not enter.

The particular system discussed fails equally with Upton's in providing effective formations for fighting, and is inferior to the latter for manœuvring.

Lieutenant D. H. MAHAN.—I do not only form a line of skirmishers in interval order, but my interval order extends throughout all—intervals between companies, between sections, and between groups—the intervals gradually becoming shorter as the divisions become smaller, until the line has at last attained the consistency of a line of battle, when the assault is to be made.

The Prussian tactics, devised in 1847 and developed in 1866 and 1870–71, have been kept alive (if we can believe semi-official rumors) only by the old Kaiser's wish that the tactics should not be changed during his lifetime, but now we hear of a great change in German tactics, which is awaited with much interest.

I have judged it was impossible to bring troops into action in column or in line, hence the subdivision of my line or column becoming smaller and smaller, but with the ultimate object of forming into that "individual order" which Lieutenant Kennon desires. The space I allow, with all my men in the firing line, is about five yards to every three men—a little more space than the Germans allow, and if exposed to the fire of such a gun as the Maxim, scarcely enough.

Considering myself that "the fire of a line of troops in interval order was insufficient to accomplish decisive results," I make an allowance for keeping my men together until such time as I conceive it necessary to form smaller assemblies.

Mr. Kennon says the French make no provision whatever for a line of skirmishers in open or extended order. Let me quote a few words from the "Ecole de Bataillon": "At 800 meters rifle fire becomes dangerous, the groups extend in rear of the scouts, who, being picked marksmen, open fire in reply

to that of the enemy. The fighting line pushes on from shelter to shelter, and as soon as it becomes necessary to do so, in order to ensure superiority, the 'chaine' joins the scouts." What is this "chaine"? "The 'chaine' is formed of 'escouades,' each consisting of from four to seven files at six paces interval. These 'escouades' (groups) do not, however, at once extend . . . . until the enemy's fire is felt, when the group extends." What are these scouts allowed at the rate of two to every group? Upton's Nos. 1 and 3 of the front rank as skirmishers.

Suppose we consider (in reference to the front of 560 or 360 paces) the attack I have mentioned in column of companies. Deploying as mentioned, I have a "medley of masses" composed of a "medley of men." The first company deployed in a group formation until necessary to move into the firing line; the second company in section formation, breaking into groups and then into "individual order," ultimately rushing up to the firing line; the third company marching as a company in reserve, then broken into sections and then into groups, until in their turn rushed forward into the firing line, which now has (barring casualties) 300 men in the 560 or 360 paces. By this mode of attack will be brought about the mingling of different tactical units, for on the right I would have the right sections of three companies and so on along the line. When I deploy my company I have said the rushes will be by sections—if a battalion were deployed the rushes would be by companies, if possible, otherwise by sections—I wish to rush as many men as possible commensurate with safety (although everything must be risked to win); this causes a "succession of rushes." I say that the assemblies or rallies should take place (not at the same time along the line) if necessary. Would this not allow the old skirmishers to double up with the new detachment coming up? My system allows for the dispersing of tactical units, but at the same time strives to have some order come out of such chaos as Von Boguslawski presents to us.

In regard to the number of intermediate links being a defect, "a complete maintenance of the chain of responsibility, from the commander-in-chief down to the leader of the smallest squad in the fighting line," is called for by the armies of Germany, France, and Austria. In deploying in the firing line is the only time that the leader in the rear rank assumes any responsibility. Consequently the front rank leader is the one, and is one sixth instead of one third of the group. To show that they are used in other armies, let us consider the "sammeln" of the Austrian army. It means a "forward assembly," and is thus performed. A body is in close or open order and wishes to cross a patch of open ground exposed to fire. *The leader* points out the place where *he* wishes the men to assemble, and they run across to it singly or in files and reform. (The "schwarmline" consists of groups, each containing from four to seven files.) Is not *the leader* in my squad, and is it not for him to act as above, command he three or six men? I would call Mr. Kennon's attention to my remarks in answer to Mr. Fullam and Mr. Haeseler in regard to deployments. I think in that it is superior to Upton; the distances can of course be diminished if practice should require it. I have not seen any evidence that this system is inferior to the latter for manœuvring.

In closing my remarks, I would like to present my thanks to the gentlemen who have evinced interest enough in my article to criticise it.

There has been, however, a great diversity of opinion expressed, but in summing up all the differences it seems to me that they dwindle down to three faults—orders, distances, and counting off. Of these I would like to say that a new system should have orders suited to it, and as one of my divisions is a section, I could not use the command "platoon." The order "to the right march" causes the men to move by the right flank, but saves the word flank; the wheels remain the same. Distances are never arbitrary, they can always be changed at discretion; much has to be left to the senior in command. Counting off should be done away with, but only by continual practice can men be accustomed to take nearly the same positions. I have selected eighteen men, as there are but nine in the front rank, nine in the rear rank, and these should be continually trained together, and besides it is in accord with my system.

Finally, I would like to quote a few remarks from a careful analysis of the general principles accepted by three of the great continental powers, compiled by Sir Lumley Graham.

(3) "For the front or 'firing line' the only formation, both in attack and defense, is a line of small sections extended in single rank (which is called a line of skirmishers), which, from being at first *very open*, becomes more and more dense as the antagonists come to close quarters, attaining at last almost the consistency of a line in close order." Does not my attack from column of companies fulfill this point?

(5) "The intermixture of tactical units, which, under the present conditions of warfare, occurs more frequently and on a larger scale than formerly, is an inevitable evil. *All* that can be done is to put it off to a late stage of the battle by means of tactical dispositions, and to minimize its bad effects by training and discipline." Does not my system do nearly all that can be done? Do not tactical dispositions necessitate other dispositions of command, and do I not provide for these dispositions by endeavoring to maintain a thorough command?

(6) "The same training and discipline must regulate infantry fire. If this is to be of decisive effect it must not only be hot and well sustained, but it must also be *entirely under control*, and conducted according to fixed principles, so as to be concentrated upon any point desired." Is not the fire of my system "entirely under control," and "so as to be concentrated on any fixed point"?

(8) "The comparatively loose formations necessary in the present day render supervision and control on the part of superiors more difficult. Tactical dispositions will again do something to remedy this evil, but thorough discipline and training will do more, contributing as they will to the complete maintenance of the chain of responsibility, from the commander-in-chief right down to the leader of the smallest squad in the fighting line." Does not my system do this; is there not a chain right down to the leader of the squad of three?

(16) "In order to get the full value out of the present armament, infantry

should be trained to firing by companies and *smaller bodies* at *long range*, but such firing should only be by word of command." This also can be accomplished by my system, the smaller bodies being groups and sections and all under command.

I should also like to make a few comparisons. "A German company, on a war footing (when manœuvring), is divided into three divisions (zuge), six half divisions (halb-zuge), and twelve sections." My company, on a war footing, is divided into three sections, six half sections, eighteen groups. With the German company when skirmishing, groups of from four to seven files are formed. My groups are three files, but there can be six or nine files.

"An Austrian company on a war footing is divided into two half companies." Is not mine practically so divided?

"In France the company is divided into three echelons. One section forms the fighting line, another the support, the third and fourth sections the reserve. The fighting line is formed of groups, each consisting of from four to seven files at six paces interval. These groups do not, however, immediately extend; on the contrary, each group remains in close order. . . . . This formation is preserved until the enemy's fire is felt, when the group extends." Is not this a good deal similar to my formation? My groups are three files and nine files, but wider separated than the French. My movements in groups are similar, except I have no sharpshooters to throw forward. There are many other points in which my plan can be said to resemble the German, French, and Austrian systems.

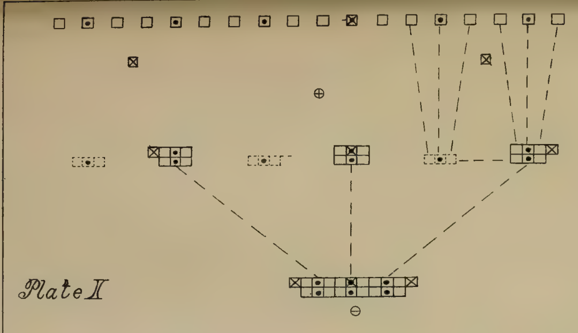
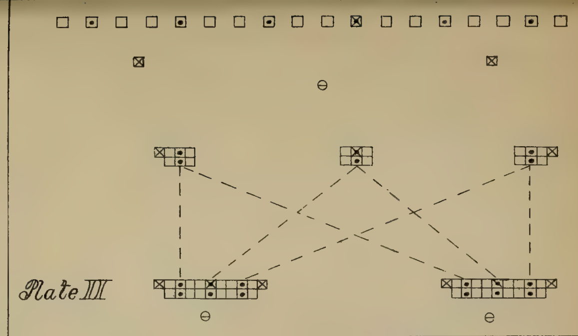


Plate I



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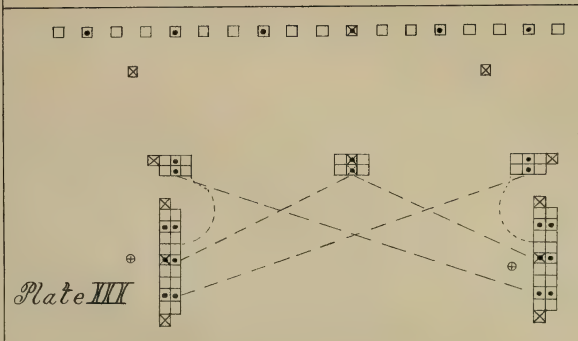

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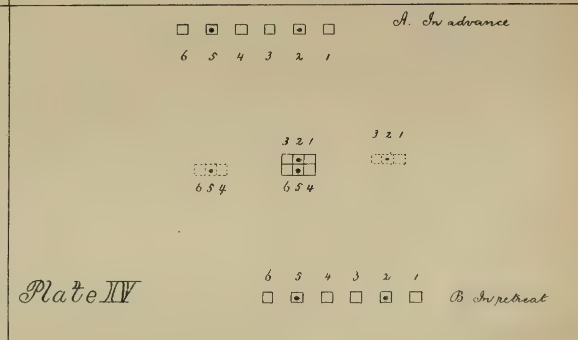

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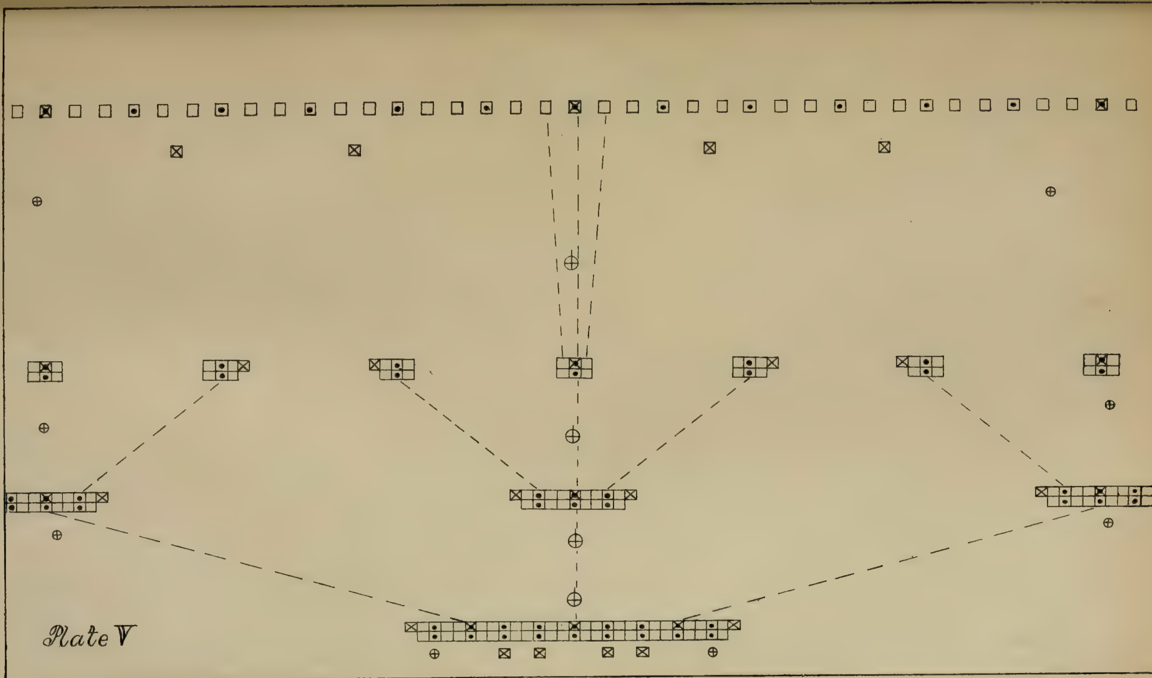
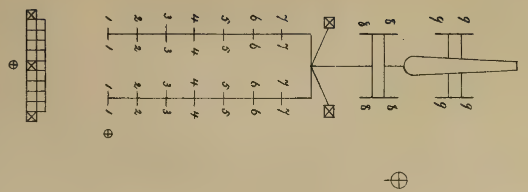
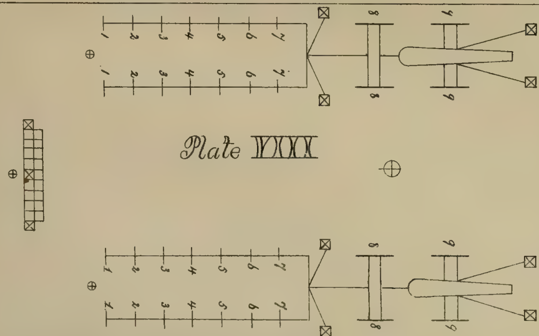


Plate V

Plate VII





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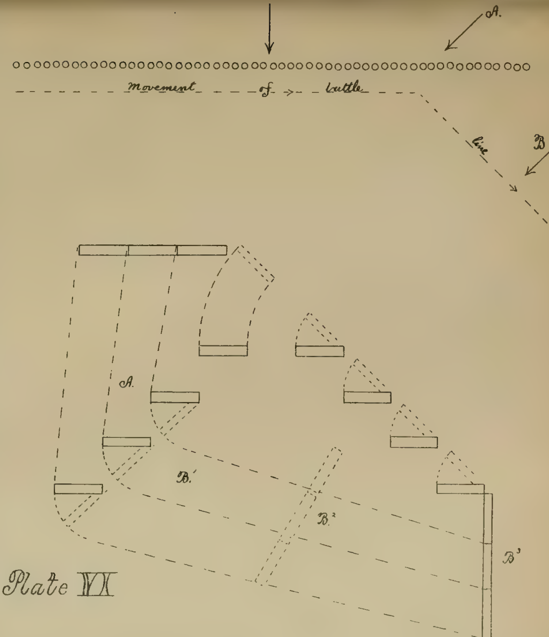
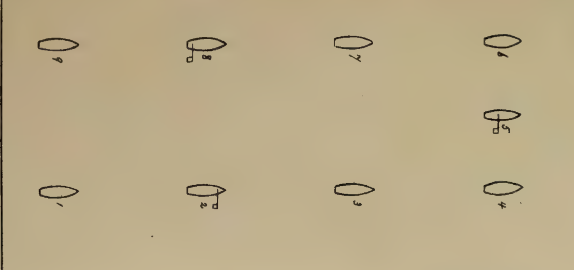


Plate VI

Plate X



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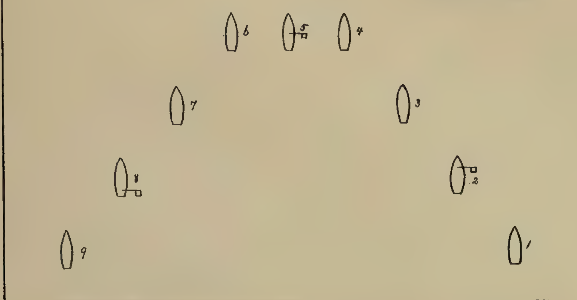
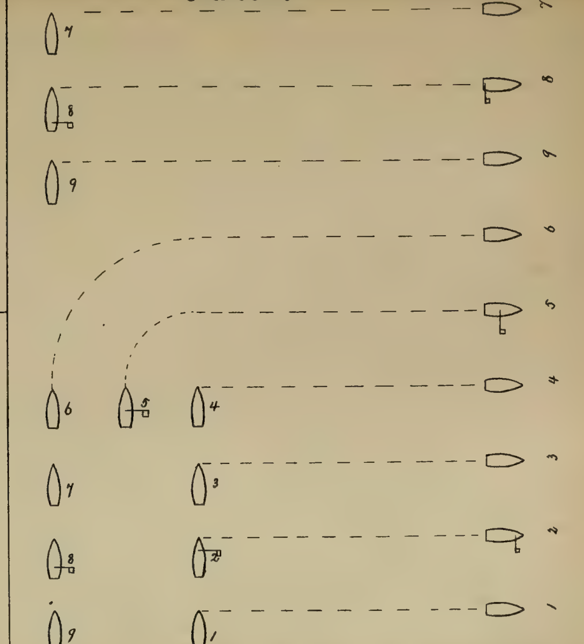


Plate XX



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

VELOCITIES AND PRESSURES IN GUNS.

By Ensign J. H. Glennon, U. S. N.*

When powder is burnt, either in the open air or in a closed vessel, the products are not all gaseous—a considerable quantity of solid residue is left. The experiments of Messrs. Noble and Abel with varying quantities of powder in a closed vessel furnish data for the calculation of the volume of this solid residue. The pressure, measured with a pressure gauge, is given in each case. As these pressures necessarily follow Mariotte's law, the volume occupied by the powder gases, alone, can be found in each case. This, subtracted from the volume of the vessel, gives the volume of the solid residue. The results obtained by Messrs Noble and Abel, and the calculations of M. Sarrau, point to the fact that the volume of the solid residue, left on exploding powder, is almost exactly equal to the volume of the powder. Assuming this equality, the questions on powder in guns are very much simplified. It is plain in such a case, whether the powder is all burnt at any point or not, that the volume of solid matter, in the bore of a gun when fired, is at all times equal to the original volume of the powder (*exclusive of interstices*).

With the projectile at any point in the bore of a gun, the volume occupied by the gaseous products of powder can be readily calculated by finding the volume of the bore to that point and subtracting from this the volume of the powder.

If δ is the specific gravity or density of the powder, the volume in liters occupied by a weight W of powder, in kilograms, is evidently $\frac{W}{\delta}$. If the volume of the chamber in liters is C, the portion of the chamber unoccupied by solid matter is evidently $C - \frac{W}{\delta}$.

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This is the initial air-space in a gun. By adding to the initial air-space the volume of the bore from the seat of the projectile to the base of the projectile at any point in its travel, we obtain the volume occupied by the gaseous products of combustion for that travel of projectile. Usually the ratio of this latter volume to that of the initial air-space is what is required. This ratio is more readily found by using the *reduced lengths* of these two volumes, which reduced lengths may be defined as being the heights of right cylinders whose volumes are those given, and whose diameters are the caliber of the gun. If c is the caliber of the gun, $\dfrac{C-\dfrac{W}{\delta}}{\dfrac{\pi c^2}{4}}$ is the reduced length of the initial air-space. For simplicity, $\dfrac{\pi c^2}{4}$ will be denoted by ω. Denoting the reduced length of the initial air-space by L,

$$L=\left(C-\frac{W}{\delta}\right)\frac{1}{\omega},$$

$$\therefore\quad L=\frac{W}{\omega}\left(\frac{C}{W}-\frac{1}{\delta}\right).$$

Density of loading is the ratio of the weight of the charge to the weight of a volume of water that would fill the powder chamber, or is the weight of the charge in kilograms divided by the volume of the chamber in liters. It is evidently the mean density of the products of combustion when they are supposed to fill the powder chamber.

It is denoted by Δ, $\therefore\ \Delta=\dfrac{W}{C}$. Substituting this in the value of L, we have

$$L=\frac{W}{\omega}\left(\frac{1}{\Delta}-\frac{1}{\delta}\right).$$

If u represents any travel of the shot in a gun, $\dfrac{u+L}{L}$ is the ratio of the volume occupied by the gases, when the projectile is at u, to the initial air-space.

There are two principal hypotheses on the action of powder in the bore of a gun:

1st. That the gaseous products of combustion receive heat from the solid products as the gas expands, the two being in equilibrium of temperature.

2d. That the gaseous products neither receive nor give off heat, but expand adiabatically.

The 2d is the one followed in this paper. It is true that heat is lost to the walls of the gun, but probably no more than can be accounted for by radiation from the solid residue, the radiating power of which is probably very great, while the emissive and absorptive properties of the gases are probably very small.

If x represents the weight of gaseous products in the bore of a gun at any time;

T_0, the absolute temperature of combustion of powder, or the absolute temperature that the gases would have if no work were done by their expansion;

T, the absolute temperature of the gases in the bore when the projectile is at any point of travel u;

c_1 the specific heat of the gases in constant volume, and

E the mechanical equivalent of heat; evidently we have

$$\text{Heat converted into work} = c_1 x\,(T_0 - T),$$

or

$$\frac{\text{work done}}{E} = c_1 x\,(T_0 - T). \qquad (a)$$

With a unit weight (kilogram) of gas, $P_1 V = RT$, where P_1 is the pressure per unit of area when the gas occupies a volume V at absolute temperature T. The value of R in this equation will give the mechanical equivalent of heat if we divide it by $c' - c_1$, where c' is the specific heat of the gas under constant pressure.* Then

$$E = \frac{R}{c' - c_1} = \frac{R}{c_1\left(\dfrac{c'}{c_1} - 1\right)}.$$

Substituting this in equation (a), calling $\dfrac{c'}{c_1}$, n, and dividing through by c_1,

$$(n - 1)(\text{work done}) = Rx\,(T_0 - T) = RxT\left(\frac{T_0}{T} - 1\right). \qquad (b)$$

In the equation above, $P_1 V = RT$, we had a unit weight of gas in volume V. If we have any other weight of gas as x in this same volume, by Mariotte's law the pressure will be multiplied by x, the temperature still remaining T; or if P denote the new pressure,

$$PV = RxT.$$

Equation (b) then becomes,

$$(n - 1)(\text{work done}) = PV\left(\frac{T_0}{T} - 1\right) = PV\frac{T_0}{T} - PV, \qquad (c)$$

* This is one method of determining the mechanical equivalent of heat. See equation 13, page 5, Vol. X., No. 1, Whole No. 28, Proceedings U. S. Naval Institute.

where P is the pressure of the gases in the bore of a gun, and V the volume these gases occupy.

We can still further reduce equation (c) by introducing another function of powder.

The force of powder is the pressure per unit of area (square decimeter) of the gases of a unit weight of powder (kilogram) exploded in a space such that the gaseous products shall occupy a unit volume (liter). It is denoted by f.

If then we explode w kilograms* of powder so that its gases shall occupy a liter, by Mariotte's law the pressure per unit area will be fw. If these gases occupy V liters, instead of one liter, the pressure per unit area will be $\frac{fw}{V}$; and if the temperature of the gases is changed, by work or any other cause, the pressure will be changed proportionally to the absolute temperature. Consequently at temperature T the pressure will be

$$P = \frac{fw}{V} \cdot \frac{T}{T_0} \therefore \; PV\frac{T_0}{T} = fw.$$

Substituting this in (c),

$$(n-1)(\text{work done}) = fw - PV.$$

If m is the mass of the projectile, and if the energy of the projectile represents the work done,

$$(n-1)\frac{m}{2}\left(\frac{du}{dt}\right)^2 = fw - PV, \text{ or } \frac{n-1}{2}\left(\frac{du}{dt}\right)^2 = \frac{fw}{m} - \frac{PV}{m}. \quad (d)$$

If P is the pressure per unit area on the projectile, $P\omega$ is the entire pressure on its base and $\frac{P\omega}{m}$ is its acceleration. Consequently

$$\frac{P\omega}{m} = \frac{d^2u}{dt^2}.$$

V, the volume occupied by the gases, is $\omega\,(u + L)$, as stated at the beginning of this paper. Consequently

$$\frac{PV}{m} = (u + L)\frac{d^2u}{dt^2}.$$

Substituting this in equation (d), we obtain the general equation of motion in the bore of a gun,

$$(u + L)\frac{d^2u}{dt^2} + \frac{(n-1)}{2}\left(\frac{du}{dt}\right)^2 = \frac{fw}{m}, \quad (1)$$

where w is the weight of powder burnt at any point, and u the corresponding travel of the projectile.

* w kilograms of powder are supposed to give off x kilograms of gas.

In a gun, unless the powder is very quick, all of it is not burnt. In case the powder is not all burnt, w is not equal to W, the weight of the charge, but is something less. If we know the value of w at any point, the solution of equation (1) for v will give us the velocity at that point. The solution for $\frac{d^2u}{dt^2}$ will give the acceleration, provided that w remains constant for the corresponding element of time dt. If w is variable during this time, $\frac{d(v^2)}{2du}$, treating w and u as variables in the formula for v^2, will be the acceleration.

In fact the expression, $P = Rx\frac{T}{V}$, used in the deduction of the general equation, is only true on the supposition that x is constant, at the point taken, which involves w being constant at the same.

To solve equation (1) it is only necessary to change its form slightly.

Since $\frac{d^2u}{dt^2} = \frac{dv}{dt}$, where v is the velocity of projectile corresponding to travel u, and $v = \frac{du}{dt}$, we have

$$dt = \frac{du}{v}, \text{ and } \frac{d^2u}{dt^2} = \frac{dv}{dt} = \frac{vdv}{du} = \frac{d(v^2)}{2du}.$$

(1) may be written

$$(u+L)\frac{d(v^2)}{2du} + \frac{(n-1)}{2}v^2 = \frac{fw}{m},$$

or

$$(u+L)\frac{d(v^2)}{du} + (n-1)v^2 - \frac{2fw}{m} = 0. \qquad (2)$$

Dividing each member of equation (2) by $\frac{u+L}{du}\left(v^2 - \frac{2fw}{(n-1)m}\right)$

we obtain

$$\frac{d(v^2)}{v^2 - \frac{2fw}{(n-1)m}} + (n-1)\frac{du}{u+L} = 0,$$

and integrating,

$$\log\left(v^2 - \frac{2fw}{(n-1)m}\right) + \log(u+L)^{n-1} + F = 0,$$

where F is the constant of integration.

When $u = 0$, $v = 0$; consequently

$$-F = \log(L)^{n-1} + \log\left(-\frac{2fw}{(n-1)m}\right) = \log\left(-\frac{2fw}{(n-1)m}L^{n-1}\right)$$

$$\therefore \left(v^2 - \frac{2fw}{(n-1)m}\right)(u+L)^{n-1} = -\frac{2fw}{(n-1)m}L^{n-1},$$

or

$$v^2 - \frac{2fw}{(n-1)m} = -\frac{2fw}{(n-1)m}\left(\frac{L}{u+L}\right)^{n-1},$$

and $$v^2 = \frac{2fw}{(n-1)m}\left(1 - \left(\frac{L}{u+L}\right)^{n-1}\right), \tag{3}$$
which will give the velocity at any point u, provided we know w for the same point.

In case w is burnt instantaneously, and no more powder is burnt in the gun, the formula for velocity can be found by direct integration, assuming that the gases expand adiabatically.

At first, the gaseous products occupy the initial air-space. Their volume then is ωL. Then their pressure per unit area is $P_c = \frac{fw}{\omega L}$. At any point u, the gases occupy a volume $\omega(u+L)$. If the transformation is adiabatic, PV^n is constant,

$$\therefore \quad P_c(\omega L)^n = P[\omega(u+L)]^n,$$
$$\therefore \quad P = P_c\left(\frac{L}{u+L}\right)^n = \frac{fw}{\omega L}\left(\frac{L}{u+L}\right)^n.$$
But $$P = \frac{m}{\omega}\cdot\frac{dv}{dt} = \frac{m}{\omega}\,\frac{d(v^2)}{2du},$$
$$\therefore \quad d(v^2) = \frac{2fw}{mL}\left(\frac{L}{u+L}\right)^n du,$$
$$\therefore \quad v^2 = \int_0^{v^2} d(v^2) = \frac{2fw}{m}\int_0^u \frac{L^{n-1}du}{(u+L)^n}$$
$$= \frac{2fw}{(n-1)m}\left(1 - \left(\frac{L}{u+L}\right)^{n-1}\right),$$
as before.

Equation (3) can be written, if we substitute for $\frac{u}{L}$, y,

$$v^2 = \frac{2fw}{(n-1)m}\left(1 - \frac{1}{(y+1)^{n-1}}\right). \tag{4}$$

If the charge is completely burned when the projectile leaves the muzzle, which would happen only with a quick powder, substituting for w the weight of charge W, and for y its value at the muzzle, we obtain a value for muzzle velocity.

It is convenient to have if possible a monomial formula for v^2. This can only be obtained by making $\left(1 - \frac{1}{(y+1)^{n-1}}\right)$ equal to the product of a power of y by a constant. n with perfect gases equals 1.4.

Suppose, then, $\left(1 - \frac{1}{(y+1)^{n-1}}\right) = \left(1 - \frac{1}{(y+1)^{.4}}\right) = Dy^\gamma$, where D and γ are unknown constants. Values of y, that will include most muzzle distances with modern guns, are 4 and 9. 4 and

9, then, as values for y, should satisfy the above equation. Substituting them, we have,

$$1 - \frac{1}{(9+1)^{.4}} = D\,(9)^{\gamma},$$

and

$$1 - \frac{1}{(4+1)^{.4}} = D\,(4)^{\gamma}.$$

Dividing the first by the second,

$$\frac{1 - \frac{1}{(10)^{.4}}}{1 - \frac{1}{(5)^{.4}}} = \left(\frac{9}{4}\right)^{\gamma},$$

whence

$$\log \frac{1 - \frac{1}{(10)^{.4}}}{1 - \frac{1}{(5)^{.4}}} = \gamma \log \frac{9}{4}, \text{ or } \gamma = \frac{\log \dfrac{1 - \frac{1}{(10)^{.4}}}{1 - \frac{1}{(5)^{.4}}}}{\log \frac{9}{4}} = .29.$$

Consequently, substituting for $1 - \frac{1}{(y+1)^{.4}}$, $Dy^{.29}$ or even $Fy^{\frac{1}{4}}$, will give very good results, F being a constant. Making the last substitution, (4) becomes $v^2 = \frac{2fFW}{(n-1)\,m} y^{\frac{1}{4}} = \frac{2fF}{(n-1)} \frac{W}{m} \left(\frac{u}{L}\right)^{\frac{1}{4}}$.

It is customary to eliminate L. To do this we have to remember that a function near its maximum varies very slowly. The quantity $\frac{\varDelta}{\delta}\left(1 - \frac{\varDelta}{\delta}\right)$ is a maximum when $\frac{\varDelta}{\delta} = \frac{1}{2}$. In the conditions of practice $\frac{\varDelta}{\delta}$ does not vary much on either side of $\frac{1}{2}$,

$$\therefore \quad \frac{\varDelta}{\delta}\left(1 - \frac{\varDelta}{\delta}\right) = \frac{1}{4}, \text{ very nearly.}$$

Now L, as before proven, equals

$$\frac{W}{\omega}\left(\frac{1}{\varDelta} - \frac{1}{\delta}\right) = \frac{W}{\omega \varDelta}\left(1 - \frac{\varDelta}{\delta}\right),$$

or

$$L = \frac{W\delta}{\omega \varDelta^2} \cdot \frac{\varDelta}{\delta}\left(1 - \frac{\varDelta}{\delta}\right),$$

$$\therefore \quad L = \frac{W\delta}{4\omega \varDelta^2}, \text{ very nearly.}$$

Substituting in the above monomial formula for v^2 this value of L, for ω its value $\frac{\pi c^2}{4}$, for m, $\frac{p}{g}$, where p is the weight of the projectile; and, as the density of powder is nearly constant, calling $\delta^{\frac{1}{4}}$ constant, and placing it, as well as F and the other numerical constants, in a new constant A^2, we have

$$v^2 = A^2 \frac{fW}{p} \left(\frac{c^2 \Delta^2}{W}\right)^{\frac{1}{3}} u^{\frac{1}{3}} = A^2 \frac{fW^{\frac{2}{3}}}{p} c^{\frac{2}{3}} \Delta^{\frac{2}{3}} u^{\frac{1}{3}},$$

$$\therefore \quad v = A \frac{f^{\frac{1}{2}}}{p^{\frac{1}{2}}} W^{\frac{1}{3}} c^{\frac{1}{3}} \Delta^{\frac{1}{3}} u^{\frac{1}{6}}, \tag{5}$$

which is the monomial formula for muzzle velocity, using a powder all of which is burnt in the gun. This formula agrees with experiment. It differs from that of M. Sarrau in one point. He introduces with f another quantity depending on the shape of the powder-grain. As can be seen, however, from the fundamental equation (1) (with which M. Sarrau commences), there can be only one solution for v, for any given value of w, if f is constant.

With slower powders we have to proceed in a different way; w is then less than W, as all the powder is not burnt in the gun. From (4) we have

$$\left(\frac{dy}{dt}\right)^2 = \left(\frac{du}{Ldt}\right)^2 = \frac{v^2}{L^2} = \frac{2fw}{(n-1)mL^2}\left(1 - (y+1)^{1-n}\right). \tag{6}$$

From (4), by differentiation, we have*

$$\frac{d^2u}{dt^2} = \frac{d(v^2)}{2du} = \frac{d(v^2)}{2Ldy} = \frac{fw}{mL(y+1)^n}. \tag{7}$$

Dividing (7) by (6), member by member,

$$\frac{d^2u}{(dy)^2} = \frac{(n-1)L}{2[(y+1)^n - (y+1)]} = \frac{(n-1)L}{2(y+1)[(y+1)^{n-1} - 1]},$$

$$\therefore \quad d^2u = \frac{(n-1)L(dy)^2}{2(y+1)[(y+1)^{n-1}-1]}. \tag{8}$$

Let l_τ denote the least dimension of the grains of gunpowder of which the charge is composed, the grains being supposed uniform in size, shape and material; let τ denote the time of burning of a grain at the normal atmospheric pressure P_0; and let l denote the length of grain burnt in time t, at pressure P.

The velocity of combustion† of the grain at the atmospheric pressure is evidently $\frac{l_\tau}{\tau}$. If the "velocity of combustion varies as the square root of the pressure" (see Whole No. 28, Proceedings U. S. Naval Institute, page 102), when the pressure is P, velocity of combustion $= \frac{dl}{dt} = \frac{l_\tau}{\tau}\left(\frac{P}{P_0}\right)^{\frac{1}{2}}$.

* This is the acceleration due to $P = Rx\frac{T}{V}$, the pressure of the surrounding medium previous to increase by a change in x; just as in air, P_0 is the pressure previous to a corresponding increase. In either case, if the phenomenon were suddenly stopped, $P = Rx\frac{T}{V}$ and P_0 would be the measured pressures.

† *Velocity of combustion* as here used means twice what is ordinarily understood by that name. With a spherical grain, for example, it is the decrease per second in the length of the diameter.

Substituting for P its value, or $\frac{m}{\omega}\frac{d^2u}{dt^2}$, we have,

$$dl = \frac{l_\tau}{\tau}\left(\frac{m}{\omega P_0}\right)^{\frac{1}{2}}\left(\frac{d^2u}{dt^2}\right)^{\frac{1}{2}} dt = \frac{l_\tau}{\tau}\left(\frac{m}{\omega P_0}\right)^{\frac{1}{2}}(d^2u)^{\frac{1}{2}}.$$

Substituting for d^2u its value from equation (8),

$$dl = \frac{l_\tau}{\tau}\left(\frac{m(n-1)L}{2\omega P_0}\right)^{\frac{1}{2}} \frac{dy}{(y+1)^{\frac{1}{2}}[(y+1)^{n-1}-1]^{\frac{1}{2}}}. \quad (9)$$

Integrating (9), replacing $(n-1)$ by .4 or $\frac{2}{5}$,

$$l = \int_0^l dl = \frac{l_\tau}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}}\int_0^y \frac{dy}{(y+1)^{\frac{1}{2}}\sqrt{(y+1)^{\frac{2}{5}}-1}}. \quad (10)$$

The last integral is evidently a function of y alone; denote it by Y_1, and place $\frac{1}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}} = K$. Then (10) becomes $l = l_\tau K Y_1$, or

$$\frac{l}{l_\tau} = KY_1. \quad (11)$$

The weight of powder burned, when l is burned, can be expressed with any form of grain by

$$w = \frac{Wal}{l_\tau}\left(1 - \lambda\frac{l}{l_\tau} + \mu\frac{l^2}{l_\tau^2} + \text{etc.}\right),$$

(with most regular forms, by these three terms alone), where a, λ and μ are fixed numerical constants depending on the form of the grain. Substituting in this equation the value of $\frac{l}{l_\tau}$ from (11),

$$w = WaKY_1(1 - \lambda KY_1 + \mu K^2 Y_1^2),$$

and substituting this for w in (4),

$$v^2 = \frac{2fa\,WKY_1}{\frac{2}{5}m}(1 - \lambda KY_1 + \mu K^2 Y_1^2)\left(1 - \frac{1}{(y+1)^{.4}}\right). \quad (12)$$

Calling $Y_1\left(1 - \frac{1}{(y+1)^{.4}}\right)$, Y_0, and extracting the square root of (12), retaining two terms,*

$$v = \left(\frac{5fa\,WK}{m}\right)^{\frac{1}{2}} Y_0^{\frac{1}{2}}\left[1 - \frac{\lambda}{2}KY_1\right]. \quad (13)$$

It is evident that the formula for velocity thus depends for complete solution entirely on the form of Y_1. M. Sarrau assumes Y_1 proportional to $y^{\frac{1}{2}}$. As will be seen later, this power is very approximate. The quantity $\left(1 - \frac{1}{(y+1)^{.4}}\right)$, as stated before, for muzzle distances, varies very nearly as $y^{\frac{1}{4}}$. Consequently Y_0 varies

* The remaining terms are small, and the experimental method afterwards pursued of determining the constants in the second member of (13) almost entirely eliminates the error due to their omission.

very nearly as $y^{\frac{3}{4}}$. Placing $Y_1 = Hy^{\frac{1}{2}} = H\left(\frac{u}{L}\right)^{\frac{1}{2}}$, and

$$Y_0 = H_1^2 y^{\frac{3}{4}} = H_1^2 \left(\frac{u}{L}\right)^{\frac{3}{4}},$$

where H and H_1^2 are constants; replacing K by its value $\frac{1}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}}$; and y by $\frac{u}{L}$, equation (13) becomes,

$$v = \left(\frac{5faW}{m\tau}\right)^{\frac{1}{2}}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{4}} H_1 \left(\frac{u}{L}\right)^{\frac{3}{8}}\left[1 - \frac{\lambda}{2\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}} H \left(\frac{u}{L}\right)^{\frac{1}{2}}\right],$$

or

$$v = \left(\frac{5faW}{\tau}\right)^{\frac{1}{2}}\left(\frac{1}{5\omega P_0 m}\right)^{\frac{1}{4}} \frac{1}{L^{\frac{1}{8}}} H_1 u^{\frac{3}{8}}\left[1 - \frac{\lambda}{2\tau}\left(\frac{m}{5\omega P_0}\right)^{\frac{1}{2}} H u^{\frac{1}{2}}\right]. \quad (14)^*$$

Substituting for L as before (see deduction of equation (5)), $\frac{W\delta}{4\omega\Delta^2}$, for m, $\frac{p}{g}$, for ω, $\frac{\pi c^2}{4}$, calling $\delta^{\frac{1}{8}}$ a constant, and combining all the constants outside the brackets in (14) in a new constant A, and all inside in a new one B,

$$v = \frac{A f^{\frac{1}{2}} a^{\frac{1}{2}} W^{\frac{3}{8}} \Delta^{\frac{1}{4}} u^{\frac{3}{8}}}{\tau^{\frac{1}{2}} p^{\frac{1}{4}} c^{\frac{1}{4}}}\left[1 - \frac{\lambda}{\tau} B \frac{p^{\frac{1}{2}} u^{\frac{1}{2}}}{c}\right],$$

or as this is usually written,

$$v = A\left(\frac{fa}{\tau}\right)^{\frac{1}{2}} (Wu)^{\frac{3}{8}} \left(\frac{\Delta}{pc}\right)^{\frac{1}{4}}\left[1 - B\frac{\lambda}{\tau}\frac{(pu)^{\frac{1}{2}}}{c}\right]. \quad (15)$$

This agrees exactly with Sarrau's formula and with experiment. The two constants A and B are determined by the actual muzzle velocities obtained (for v) in two dissimilar guns. If weights are given in lbs., and distances in feet, A and B will involve the numerical quantities for the conversion of units. $\left(\frac{fa}{\tau}\right)$ and $\left(\frac{\lambda}{\tau}\right)$ are constant for the same powder, and are generally included in the determined constants.

It is not necessary, however, to substitute for Y_1, $Hy^{\frac{1}{2}}$, inasmuch as Y_1 can be computed without much trouble.

We have $$Y_1 = \int_0^y \frac{dy}{(y+1)^{\frac{1}{2}}\sqrt{(y+1)^{\frac{2}{5}} - 1}}.$$

Place $$x = (y+1).$$

* Note in equation (14) that L occurs to the $\frac{1}{8}$ power. A small inexactness then in the assumption that the volume of the solid residue equals that of the powder will cause little or no error.

Then $$Y_1 = \int_1^x \frac{dx}{x^{\frac{1}{5}}\sqrt{x^{\frac{2}{5}}-1}}.$$

Let $X = x^{\frac{1}{5}}$, whence $x = X^5$, $dx = 5X^4 dX$, and

$$Y_1 = 5\int_1^X \frac{X^{\frac{3}{2}}dX}{\sqrt{X^2-1}}.$$

Let $$X = \sec\varphi \quad \therefore \quad dX = \sec\varphi\tan\varphi d\varphi,$$

and $$Y_1 = 5\int_0^\phi (\sec\varphi)^{\frac{5}{2}}d\varphi.$$

Now,

$$\int (\sec\varphi)^{\frac{5}{2}}d\varphi = (\sec\varphi)^{\frac{3}{2}}\tan\varphi - \int \tan\varphi d(\sec\varphi)^{\frac{3}{2}}, \qquad (16)$$

and

$$\int \tan\varphi d(\sec\varphi)^{\frac{3}{2}} = \int \tan\varphi \frac{d(\sec\varphi)}{2(\sec\varphi)^{\frac{1}{2}}} = \frac{1}{2}\int \frac{\tan^2\varphi\sec\varphi d\varphi}{(\sec\varphi)^{\frac{1}{2}}};$$

or since $$\tan^2\varphi = \sec^2\varphi - 1,$$

$$\int \tan\varphi d(\sec\varphi)^{\frac{3}{2}} = \frac{1}{2}\int (\sec\varphi)^{\frac{5}{2}}d\varphi - \frac{1}{2}\int (\sec\varphi)^{\frac{1}{2}}d\varphi.$$

Substituting this in equation (16),

$$\frac{3}{2}\int (\sec\varphi)^{\frac{5}{2}}d\varphi = (\sec\varphi)^{\frac{3}{2}}\tan\varphi + \frac{1}{2}\int (\sec\varphi)^{\frac{1}{2}}d\varphi,$$

$$\therefore \quad \int_0^\phi (\sec\varphi)^{\frac{5}{2}}d\varphi = \frac{2}{3}(\sec\varphi)^{\frac{3}{2}}\tan\varphi + \frac{1}{3}\int_0^\phi (\sec\varphi)^{\frac{1}{2}}d\varphi,$$

and

$$Y_1 = 5\int_0^\phi (\sec\varphi)^{\frac{5}{2}}d\varphi = \frac{10}{3}(\sec\varphi)^{\frac{3}{2}}\tan\varphi + \frac{5}{3}\int_0^\phi (\sec\varphi)^{\frac{1}{2}}d\varphi, \qquad (17)$$

where $$\varphi = \sec^{-1}X = \sec^{-1}x^{\frac{1}{5}} = \sec^{-1}(y+1)^{\frac{1}{5}}.$$

Now,

$$\int_0^\phi (\sec\varphi)^{\frac{1}{2}}d\varphi = \int_0^\phi \frac{d\varphi}{(\cos\varphi)^{\frac{1}{2}}} = \int_0^\phi \frac{d\varphi}{\left(\cos^2\frac{\varphi}{2} - \sin^2\frac{\varphi}{2}\right)^{\frac{1}{2}}}$$

$$= \int_0^\phi \frac{d\varphi}{\left(1 - 2\sin^2\frac{\varphi}{2}\right)^{\frac{1}{2}}}.$$

Let $x_1 = \sin\frac{\varphi}{2}$; then $\frac{\varphi}{2} = \sin^{-1}x_1$, and $d\varphi = \frac{2dx_1}{\sqrt{1-x_1^2}}$,

$$\therefore \quad \int_0^\phi (\sec\varphi)^{\frac{1}{2}}d\varphi = \int^{x_1} \frac{2dx_1}{(1-x_1^2)^{\frac{1}{2}}(1-2x_1^2)^{\frac{1}{2}}}$$

$$= \sqrt{2}\int_0^{y_1} \frac{dy_1}{\left(1-\frac{y_1^2}{2}\right)^{\frac{1}{2}}(1-y_1^2)^{\frac{1}{2}}},$$

where $$x_1 = \frac{y_1}{\sqrt{2}}.$$

Let $y_1 = \sin\varphi_1$; then $\varphi_1 = \sin^{-1} y_1$, and $d\varphi_1 = \dfrac{dy_1}{\sqrt{1 - y_1^2}}$,

$$\therefore \int_0^{\phi} (\sec\varphi)^{\frac{1}{2}} d\varphi = \sqrt{2} \int_0^{\phi_1} \frac{d\varphi_1}{\left(1 - \frac{1}{2}\sin^2\varphi_1\right)^{\frac{1}{2}}}, \tag{18}$$

where $\varphi_1 = \sin^{-1} y_1 = \sin^{-1}(\sqrt{2}x_1) = \sin^{-1}\left(\sqrt{2}\sin\dfrac{\varphi}{2}\right)$,

and $$\varphi = \sec^{-1}(y + 1)^{\frac{1}{5}}.$$

The last integral is evidently of the general form

$$\int_0^{\phi} \frac{d\varphi}{(1 - k^2 \sin^2\varphi)^{\frac{1}{2}}},$$

k evidently being $\sqrt{\frac{1}{2}}$, or sin 45°.

It is tabulated under the heading F(45°), Table IX, Tome II, Fonctions Elliptiques, by Legendre (page 331), for every value of φ from 0° to 90°. Evidently then,

$$Y_1 = \frac{10}{3}(\sec\varphi)^{\frac{1}{2}}\tan\varphi + \frac{5\sqrt{2}}{3} \int_0^{\sin^{-1}\left(\sqrt{2}\sin\frac{\phi}{2}\right)} \frac{d\varphi}{\left(1 - \frac{1}{2}\sin^2\varphi\right)^{\frac{1}{2}}},$$

where $$\varphi = \sec^{-1}(y + 1)^{\frac{1}{5}}.$$

The following is the form of calculation:

Y_1 for $y = 8$.

$(y + 1) = 9$, log .95424

$(y + 1)^{\frac{1}{5}}$ log .19085

$\varphi = \sec^{-1}(y + 1)^{\frac{1}{5}} = 49°\ 52'\ 50''$

$\frac{\varphi}{2} = 24°\ 56'\ 25''$

$\frac{\varphi}{2}$ log sin 9.62498

$\sqrt{2}$ log .15052

φ_1 log sin 9.77550

$\varphi_1 = 36°\ 36'\ 30''$

$(\sec\varphi)^{\frac{1}{2}}$ log .09542

$\tan\varphi$ log .07434

$\frac{10}{3}$ log .52288

4.9277 log .69264

1st term of Y_1

F(45°) for $\varphi_1 = .66081$, log 9.82008

$\frac{5\sqrt{2}}{3}$, log .37237

2d term of $Y_1 = 1.5576$, log .19245

1st term of $Y_1 = 4.9277$

$6.4853 = Y_1$ for $y = 8$.

The values of Y_1 for values of y from 0 to 9 will be found calculated in the following table, as well as the values of Y_0 calculated from $Y_0 = Y_1\left(1 - \frac{1}{(y+1)^{.4}}\right)$. Also the values of

$$\frac{dY_1}{dy} = \frac{1}{(y+1)^{\frac{1}{2}}[(y+1)^{\frac{2}{5}} - 1]^{\frac{1}{2}}}$$

and
$$\frac{dY_0}{dy} = \left(1 - \frac{1}{(y+1)^{.4}}\right)\frac{dY_1}{dy} + Y_1 \frac{.4}{(y+1)^{1.4}}$$

(obtained by taking the derivative of the above value of Y_0).

TABLE I.

VALUES OF THE TRANSCENDENTALS Y_1† AND Y_0* AND THEIR FIRST DERIVATIVES $\frac{dY_1}{dy}$† AND $\frac{dY_0}{dy}$*.

y	$Y_1 = \int_0^y \frac{dy}{(y+1)^{\frac{1}{2}}\sqrt{(y+1)^{\frac{2}{5}}-1}}$	$1 - \frac{1}{(y+1)^{\frac{2}{5}}}$	$Y_0 = Y_1\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$	$\frac{dY_1}{dy} = \frac{1}{(y+1)^{\frac{1}{2}}\sqrt{(y+1)^{\frac{2}{5}}-1}}$	$Y_1 \frac{2}{5(y+1)^{1.4}}$	$\frac{dY_1}{dy}\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$	$\frac{dY_0}{dy} = Y_1 \frac{2}{5(y+1)^{1.4}} + \frac{dY_1}{dy}\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$
0	0	0	0	∞	0	0	0
.1	.98851	.03742	0.03699	4.8342	.34601	.18090	0.52691
.2	1.3839	.07033	0.09733	3.3178	.42886	.23335	0.66221
.4	1.9200	.12592	0.24177	2.2264	.47979	.28035	0.76014
.6	2.3115	.17138	0.39524	1.7384	.47884	.29793	0.77677
.8	2.6281	.20952	0.55064	1.4476	.46167	.30330	0.76497
1.0	2.8967	.24213	0.70137	1.2509	.43907	.30289	0.74196
2.0	3.8677	.35562	1.3754	0.77715	.33231	.27637	0.60868
3.0	4.5360	.42564	1.9307	0.58080	.26053	.24721	0.50774
4.0	5.0569	.47470	2.4005	0.47043	.21251	.22332	0.43583
5.0	5.4894	.51164	2.8086	0.39884	.17872	.20407	0.38279
6.0	5.8617	.54084	3.1703	0.34825	.15380	.18835	0.34215
7.0	6.1901	.56473	3.4958	0.31039	.13472	.17529	0.31001
8.0	6.4853	.58476	3.7924	0.28090	.11969	.16426	0.28395
9.0	6.7538	.60189	4.0650	0.25718	.10755	.15479	0.26234

* It will be noticed that the column headed Y_0 is the square of the transcendental $\frac{dy_0}{dx}$ calculated by M. Sarrau, multiplied by a constant factor, and that $\frac{dY_0}{dy}$ is his $\frac{d^2y_0}{dx}$ multiplied by a constant factor. See Proceedings U. S. Naval Institute (Whole No. 28, page 129).

† M. Sarrau does not calculate Y_1 or $\frac{dY_1}{dy}$.

In order to find a power of y that varies approximately as Y_1 we can proceed as shown before.

Let
$$Hy^\gamma = Y_1.$$
To find γ for the whole length of bore, assume $y = .1$ and $y = 9$.

Then
$$H(.1)^\gamma = .98851 = Y_1 \text{ for } y = .1,$$
$$H(9.)^\gamma = 6.7538 = Y_1 \text{ for } y = 9.$$

Dividing the second by the first,
$$(90)^\gamma = \frac{6.7538}{.98851},$$
$$\therefore \quad \gamma = \frac{\log 6.7538 - \log .98851}{\log 90} = .426,$$
or $Y_1 = Hy^{.426}$, approximately, for the whole length of bore. Sarrau, as before stated, assumes $\gamma = \frac{1}{2}$.

Between $y = .1$ and $y = .2$, $Y_1 \propto y^{.4854}$.
" $y = .1$ and $y = 4.0$, $Y_1 \propto y^{.4425}$.
" $y = 4.0$ and $y = 5.0$, $Y_1 \propto y^{.3679}$.
" $y = 5.0$ and $y = 6.0$, $Y_1 \propto y^{.36006}$.
" $y = 6.0$ and $y = 7$, $Y_1 \propto y^{.3535}$.
" $y = 7.0$ and $y = 8$, $Y_1 \propto y^{.3488}$.
" $y = 8.0$ and $y = 9$, $Y_1 \propto y^{.3443}$.

These powers of y, by using first and second differences (of the exponents), enable us to calculate Y_1 for all the fractional values of y between these limits, without the use of Legendre's tables.

The following table contains the values of log Y_1 and log Y_0 at each tenth, between $y = 4$, and $y = 9$:

TABLE II.

y.	Log Y_1.	Diff.	Log $\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$	Log Y_0.	Diff.
4.0	.70388	.00398	9.67642–10	.38030	.00775
4.1	.70786	387	9.68019	.38805	751
4.2	.71173	377	9.68383	.39556	729
4.3	.71550	368	9.68735	.40285	708
4.4	.71918	360	9.69075	.40993	688
4.5	.72278	351	9.69403	.41681	669
4.6	.72629	342	9.69721	.42350	650
4.7	.72971	334	9.70029	.43000	632
4.8	.73305	327	9.70327	.43632	617
4.9	.73632	320	9.70617	.44249	600
5.0	.73952	313	9.70897	.44849	585
5.1	.74265	306	9.71169	.45434	571
5.2	.74571	300	9.71434	.46005	556
5.3	.74871	294	9.71690	.46561	544
5.4	.75165	287	9.71940	.47105	530
5.5	.75452	281	9.72183	.47635	518
5.6	.75733	275	9.72420	.48153	505
5.7	.76008	270	9.72650	.48658	495
5.8	.76278	265	9.72875	.49153	483
5.9	.76543	260	9.73093	.49636	474
6.0	.76803	256	9.73307	.50110	464
6.1	.77059	252	9.73515	.50574	455
6.2	.77311	247	9.73718	.51029	446
6.3	.77558	243	9.73917	.51475	435
6.4	.77801	239	9.74109	.51910	429
6.5	.78040	234	9.74299	.52339	419
6.6	.78274	230	9.74484	.52758	411
6.7	.78504	226	9.74665	.53169	403
6.8	.78730	222	9.74842	.53572	394
6.9	.78952	218	9.75014	.53966	388
7.0	.79170	215	9.75184	.54354	381
7.1	.79385	212	9.75350	.54735	373
7.2	.79597	209	9.75511	.55108	368
7.3	.79806	206	9.75670	.55476	362
7.4	.80012	204	9.75826	.55838	356
7.5	.80216	201	9.75978	.56194	351
7.6	.80417	198	9.76128	.56545	344
7.7	.80615	195	9.76274	.56889	339
7.8	.80810	193	9.76418	.57228	334
7.9	.81003	190	9.76559	.57562	329
8.0	.81193	187	9.76698	.57891	322
8.1	.81380	184	9.76833	.58213	318
8.2	.81564	182	9.76967	.58531	312
8.3	.81746	180	9.77097	.58843	309
8.4	.81926	178	9.77226	.59152	305
8.5	.82104	175	9.77353	.59457	299
8.6	.82279	173	9.77477	.59756	294
8.7	.82452	170	9.77598	.60050	290
8.8	.82622	168	9.77718	.60340	286
8.9	.82790	165	9.77836	.60626	280
9.0	.82955	163	9.77951	.60906	275

Resuming equation (12), and substituting for K its value

$$\frac{1}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}},$$

for m its value $\frac{p}{g}$, and for ω its value $\frac{\pi c^2}{4}$, joining all constants in one when possible,

$$v^2 = M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0\left[1 - N\frac{\lambda}{\tau c}(pL)^{\frac{1}{2}} Y_1 + N^2\frac{\mu}{\tau^2 c^2} pL\, Y_1^2\right], \quad (19)$$

which is the general formula, using the numbers in the preceding table. For a practical working formula, $M\frac{fa}{\tau}$ and $N\frac{\lambda}{\tau}$ must be determined by firing the same powder in two dissimilar guns. In the case of the pierced cylindrical grain $\mu = 0$, and the third term disappears. In the case of the sphere, or cube, $\lambda = 1$, $\mu = \frac{1}{3}$; the quantity inside the parenthesis in (19) is very nearly a perfect square, and the equation for v (equation 20) can be used with more accuracy than can (19), if only two terms are employed. In the case of the pierced prism there is probably a small third term which can be determined experimentally by a third firing, or the velocity can be determined with two firings very accurately either by (19) using two terms, or its square root, which is

$$v = M_1\left(\frac{fa}{\tau}\right)^{\frac{1}{2}}\left(\frac{W}{c}\right)^{\frac{1}{2}}\left(\frac{L}{p}\right)^{\frac{1}{4}} Y_0^{\frac{1}{2}}\left[1 - N_1\frac{\lambda}{\tau}\frac{(pL)^{\frac{1}{2}}}{c} Y_1\right], \quad (20)$$

M_1 and N_1 being the new constants.

Pressures.—Differentiating (19),

$$P = \frac{m}{\omega}\frac{d^2u}{dt^2} = \frac{4p}{\pi c^2 g}\cdot\frac{d(v^2)}{2du} = \frac{2p\,d(v^2)}{\pi c^2 g L dy}$$

$$= \frac{2p}{\pi c^2 g L}\cdot M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}}\frac{dY_0}{dy}\left[1 - N\frac{\lambda}{\tau}\frac{(pL)^{\frac{1}{2}}}{c} Y_1 + N^2\frac{\mu}{\tau^2}\frac{pL}{c^2} Y_1^2\right]$$

$$- \frac{2p}{\pi c^2 g L}\cdot M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0\left[N\frac{\lambda}{\tau}\frac{(pL)^{\frac{1}{2}}}{c}\frac{dY_1}{dy} - 2N^2\frac{\mu}{\tau^2}\frac{pL}{c^2} Y_1\frac{dY_1}{dy}\right] \quad (21)$$

in which the constants are known from the velocity formula (19).

Equation (21) is the general equation for the pressure per unit cross section of the base of the projectile.

In case $\lambda = 0$ and $\mu = 0$, or when all the terms of (21) except the first are so small that they may be neglected, (21) becomes

$$P = \frac{2p}{\pi c^2 g L}\cdot M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}}\frac{dY_0}{dy}. \quad (22)$$

This is directly reducible to M. Sarrau's formula for maximum pressure. By reference to the tables, $\frac{dY_0}{dy}$ is found to be a maximum when $y = .6$. If then we only use one term for P as in (22), P is maximum at the same point (where $y = .6$). $\frac{dY_0}{dy}$ is .776 at this point. Substituting the value of $\frac{dY_0}{dy}$ in (22), and for L,

$$\frac{W\delta}{4\omega\Delta^2} = \frac{W\delta}{\pi c^2 \Delta^2},$$

and combining all constants in one, G, placing $\delta^{\frac{1}{2}}$ in the constant, we have

$$P = G\frac{fa}{\tau}\Delta\frac{(pW)^{\frac{1}{2}}}{c^2}, \tag{23}$$

which is M. Sarrau's formula.

The pressure on the breech-block is evidently somewhat greater than the effective* pressure on the projectile, as the powder gases are in motion at the instant of maximum pressure, and have a weight not to be neglected. The pressure due to the mean acceleration of these gases as well as that due to the acceleration of the projectile, and the pressure due to forcing the projectile, as well as to rifling, are shown in the pressure recorded by a pressure gauge in the nose of the breech-block. The ratio of this latter pressure to the effective pressure evidently increases as W increases, and decreases as p increases. The ratio is evidently nearly constant when $\frac{W}{p}$ is constant. Sarrau assumes the ratio proportional to $\left(\frac{W}{p}\right)^{\frac{1}{4}}$, as he finds experimentally that

$$P_B = K\frac{fa}{\tau}\Delta\frac{p^{\frac{1}{4}}W^{\frac{3}{4}}}{c^2} \tag{24}$$

gives very good results, P_B being the pressure per unit on the breech-block, and K a new constant.

To illustrate the working of these formulas practically it is necessary to consider the results in at least three guns. In the following calculations the rifling of the guns is not considered, nor is the resistance to forcing, except in so far as these change the constants.

The following are the actual data in the case of German cocoa powder (C_{82}), when fired in the two Navy VI-inch B. L. rifles known

* The term *effective pressure* is used in this paper to denote the pressure which causes the acceleration of the projectile.

as the South Boston gun and Dolphin's gun. All data are given in feet and pounds.

		South Boston gun.	Dolphin's gun.
Weight of charge	=	$W = 29.125$ lbs.	$W = 50$ lbs.
Travel of projectile to muzzle	=	$u = 10.$ feet.	$u = 11.62$ feet.
Density of loading	=	$\Delta = .8763$.	$\Delta = .9886$.
Weight of projectile	=	$p = 51$ lbs.	$p = 100$ lbs.
Calibre	=	$c = .50$ foot.	$c = .50$ foot.
Initial velocity	=	$v = 1685$ feet.	$v = 1836$ feet.

Density of powder $\delta = 1.867$.

Assuming $\mu = 0$, as it is, very nearly, in the pierced prism, and as we are using the same powder in both guns, calling $\frac{fa}{\tau}$ and $\frac{\lambda}{\tau}$ (which depend on the shape, size and material of the powder), constants, (19) becomes

$$v^2 = M' \frac{W}{c} \left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0 \left[1 - N' \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right], \tag{25}$$

where M' and N' are the new constants.

In the South Boston gun (using decimeters and kilograms)

$$L = \frac{W}{\omega}\left(\frac{1}{\Delta} - \frac{1}{\delta}\right),$$

or, in feet,

$$L = \frac{29.125 \times 61.025}{3.1416 \times (3)^2 \times 2.2046 \times 12}\left(\frac{1}{.8763} - \frac{1}{1.867}\right) = 1.4388 \text{ ft.},$$

taking a liter as 61.025 cubic inches, and a kilogram as 2.2046 lbs.

Similarly in the Dolphin's gun,

$$L = 1.9413 \text{ feet.}$$

In the South Boston gun at muzzle, $y = \frac{u}{L} = \frac{10}{1.4388} = 6.9504$.

In the Dolphin's gun at muzzle, $y = \frac{u}{L} = \frac{11.62}{1.9413} = 5.9856$.

By reference to Table II it is found, by interpolation, that where $y = 6.9504$, or for the South Boston gun,

$$\log Y_0 = .54188, \text{ and } \log Y_1 = .79077;$$

and for the Dolphin's B. L. R., where $y = 5.9856$,

$$\log Y_0 = .50043, \text{ and } \log Y_1 = .76766.$$

Substituting for v, W, c, etc., their values in (25), we have for S. B. gun,

$$(1685)^2 = M' [\log^{-1} 1.53239](1 - N'[\log^{-1} 2.02458]),$$

and for Dolphin's gun,

$$(1836)^2 = M' [\log^{-1} 1.64448](1 - N'[\log^{-1} 2.21274]).$$

From these simultaneous equations we obtain

$$M' = \log^{-1} 4.98252 = 96055,$$

and $$N' = \log^{-1}(7.09757-10) = .0012519.$$

Consequently for C_{82} powder in *any* gun (25) becomes

$$v^2 = [\lg^{-1} 4.98252] \frac{W}{c} \left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0 \left(1 - [\lg^{-1} 7.09751] \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right). \quad (26)$$

To verify this equation in the VIII-inch B. L. R.: In the VIII-inch B. L. R., using its full charge of 125 lbs.,

$W = 125$ lbs.

$u = 16.41$ feet.

$\Delta = .9048$.

$p = 250$ lbs.

$c = .66667$ foot.

$v = ?$.

Proceeding as before, $L = 3.2673$ feet,

$$y = \frac{u}{L} = \frac{16.41}{3.2673} = 5.0225.$$

From Table II, $Y_0 = \log^{-1} .44942$,

$Y_1 = \log^{-1} .74023$.

Substituting these values in the above equation (26), muzzle velocity $= v =$ 2022 feet, in the VIII-in. B. L. R.

If we take equation (20) and call $M_1 \left(\frac{fa}{\tau}\right)^{\frac{1}{2}}$ and $N_1 \frac{\lambda}{\tau}$, M_1' and N_1',

$$v = M_1' \left(\frac{W}{c}\right)^{\frac{1}{2}} \left(\frac{L}{p}\right)^{\frac{1}{4}} Y_0^{\frac{1}{2}} \left[1 - N_1' \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right],$$

whence in S. B. gun and Dolphin's gun,

$$1685 = M_1' [\log^{-1} .76620](1 - N_1' [\log^{-1} 2.02458]),$$

and $$1836 = M_1' [\log^{-1} .82224](1 - N_1' [\log^{-1} 2.21274].$$

Finding M_1' and N_1' as before, we have for any gun,

$$v = [\lg^{-1} 2.49305] \left(\frac{W}{c}\right)^{\frac{1}{2}} \left(\frac{L}{p}\right)^{\frac{1}{4}} Y_0^{\frac{1}{2}} \left(1 - [\lg^{-1} 6.83519] \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right), (27)$$

and substituting the values of W, c, L, p, Y_0 and Y_1 for the VIII-inch B. L. R., we have $v = 2028$ feet.

125 lbs. of C_{82} powder have never been fired in the VIII-inch B. L. R., but 122 lbs. have. Three rounds with 122 lbs. of German cocoa powder, using a 250-lb. projectile, gave muzzle velocities of 1996, 1996 and 2006, or a mean muzzle velocity of 1999. Any of

the ordinary empirical rules for muzzle velocity will answer nearly enough for such a small change as from 122 lbs. to 125 lbs. of powder.

The rule that in the same gun the muzzle velocity varies as the $\frac{4}{5}$ power of weight of charge gives for 125 lbs. of powder, in VIII-inch B. L. R., $v = 2029$ f. s. The $\frac{6}{10}$ rule gives 2028.

In the VI-inch (Dolphin's gun), when the charge is 58 lbs., the velocity is 2000 f. s.; when the charge is 50 lbs. the velocity is 1835 f. s. In this gun the velocity evidently varies as the .58 power of the weight of charge; and if this power holds, as it evidently will very approximately, in the VIII-inch, the muzzle velocity would be 2027 f. s.

Either $v = 2022$, or $v = 2028$, as deduced from the formulæ (26) and (27), is within the limit of accuracy of the chronograph reading.

By Sarrau's formula (15), using exactly the same data, the muzzle velocity in the VIII-inch B. L. R. is 2041 f. s. (See Interior Ballistics, by Lieuts. J. F. Meigs and R. R. Ingersoll, page 91.)

Pressures.—The effective pressure on the base of the projectile is readily found, assuming equation (26).

Equation (26) becomes for the three guns under consideration, substituting for W, c, L and p their values,

for South Boston VI-inch,

$$v^2 = [\log^{-1} 5.97303]\, Y_0 (1 - [\log^{-1} 8.33132]\, Y_1);$$

for Dolphin's VI-inch,

$$v^2 = [\log^{-1} 6.12657]\, Y_0 (1 - [\log^{-1} 8.54259]\, Y_1);$$

for VIII-inch B. L. R.,

$$v^2 = [\log^{-1} 6.31365]\, Y_0 (1 - [\log 8.72967]\, Y_1).$$

The effective pressure on the base of the shot is $\dfrac{md(v^2)}{2du}$, and the effective pressure per *square inch* is $\dfrac{md(v^2)}{2\omega du}$, taking ω in square inches;

$$\therefore \quad P = \frac{md(v^2)}{2\omega du} = \frac{4pd(v^2)}{2\pi c^2 g du} = \frac{2p}{\pi c^2 g L} \cdot \frac{d(v^2)}{dy},$$

where c is in inches.

Differentiating the three equations for v^2 above;—in S. B. gun,

$$\frac{d(v^2)}{dy} = [\log^{-1} 5.97303] \frac{dY_0}{dy}$$
$$- [\log^{-1} 4.30435]\, Y_1 \frac{dY_0}{dy} - [\log^{-1} 4.30435]\, Y_0 \frac{dY_1}{dy};$$

in Dolphin's gun, $\dfrac{d(v^2)}{dy} = [\log^{-1} 6.12657] \dfrac{dY_0}{dy}$

$$- [\log^{-1} 4.66916]\, Y_1 \frac{dY_0}{dy} - [\log^{-1} 4.66916]\, Y_0 \frac{dY_1}{dy};$$

in VIII-inch, $\frac{d(v^2)}{dy} = [\log^{-1} 6.31365] \frac{dY_0}{dy}$

$$- [\log^{-1} 5.04332] Y_1 \frac{dY_0}{dy} - [\log^{-1} 5.04232] Y_0 \frac{dY_1}{dy}.$$

Calling g 32.2, and substituting for p, π, c, g and L their values, we have,

in South Boston gun,

$$P = [\log^{-1} 8.29930] \frac{d(v^2)}{dy};$$

in Dolphin's gun, $P = [\log^{-1} 8.45162] \frac{d(v^2)}{dy};$

in VIII-inch, $P = [\log^{-1} 8.37359] \frac{d(v^2)}{dy};$

and the final values of P, the effective pressure per square inch on the base of the projectile, are, in the South Boston VI-inch B. L. R.,

$$P = [\log^{-1} 4.27233] \frac{dY_0}{dy}$$

$$- [\log^{-1} 2.60365] Y_1 \frac{dY_0}{dy} - [\log^{-1} 2.60365] Y_0 \frac{dY_1}{dy};$$

in the Dolphin's VI-inch B. L. R.,

$$P = [\log^{-1} 4.57819] \frac{dY_0}{dy}$$

$$- [\log^{-1} 3.12078] Y_1 \frac{dY_0}{dy} - [\log^{-1} 3.12078] Y_0 \frac{dY_1}{dy},$$

and in the VIII-inch B. L. R.,

$$P = [\log^{-1} 4.68724] \frac{dY_0}{dy}$$

$$- [\log^{-1} 3.41691] Y_1 \frac{dY_0}{dy} - [\log^{-1} 3.41691] Y_0 \frac{dY_1}{dy}.$$

The following table, compiled from Table I, will be of use:

TABLE III.

y.	$\log\left(\frac{dY_0}{dy}\right) + 10$.	$\log\left(Y_1 \frac{dY_0}{dy}\right)$.	$\log\left(Y_0 \frac{dY_1}{dy}\right)$.
0.1	9.72174	9.71672−10	9.25241−10
.2	9.82100	9.96211−10	9.50910−10
.4	9.88089	0.16419	9.73102−10
.6	9.89029	.25419	9.83701−10
.8	9.88364	.30329	9.90152−10
1.0	9.87038	.33229	9.94318−10
2.0	9.78439	.37184	0.02894
3.0	9.70564	.36231	.04974
4.0	9.63932	.34320	.05280
5.0	9.58296	.32248	.04929
6.0	9.53422	.30225	.04299
7.0	9.49137	.28307	.03546

The following calculation will illustrate the method of procedure in each case:

Effective pressure in the South Boston gun when $y = .6$, or $u = Ly = 1.4388 \times .6 = .86328$ feet.

$\frac{dY_0}{dy}$ log 9.89029	$Y_1 \frac{dY_0}{dy}$ log 0.25419	$Y_0 \frac{dY_1}{dy}$ 9.83701
4.27233	2.60365	2.60365
14542 log 4.16262	721 log 2.85784	275 log 2.44066
996	275	
$P = 13546$ lbs. per sq. inch.	996	

Proceeding in the same way for all three guns, we obtain the following table of effective pressures per square inch on the base of the projectile:

y.	South Boston VI-in. B.L.R.		VI-in. B.L.R. (Dolphin).		VIII-in. B. L. R.	
	u (feet).	P (lbs.).	u (feet).	P (lbs.).	u (feet).	P (lbs.).
.1	.144	9583	...	...	...	...
.2	.29	11900	.39	23435	0.65	28991
.4	.58	13429	.78	26142	1.3	31777
.6	.86	13546	1.16	26130	1.96	31319
.8	1.15	13194	...	...	2.61	29897
1.0	1.44	12675	...	...	3.27	28205
2.0	2.88	10021	...	...	6.53	20683
3.0	4.32	8131	5.82	14701	9.80	15768
4.0	5.76	6821	...	...	13.06	12506
5.0	7.19	5873	...	...	16.33	10217
6.0	8.63	5159	11.62	8847	...	...
7.0	10.00	4598	...	...	...	...

Resuming the muzzle velocity formula of M. Sarrau, equation (15), placing $\frac{fa}{\tau}$ and $\frac{\lambda}{\tau}$ in the constants, the formula for muzzle velocity, using any fixed powder, becomes

$$v = A_1 (Wu)^{\frac{3}{8}} \left(\frac{\Delta}{pc}\right)^{\frac{1}{4}} \left[1 - B_1 \frac{(pu)^{\frac{1}{2}}}{c}\right].$$

If the gun remains the same, as well as the weight of charge and projectile, the equation can be still further simplified to

$$v = A_2 u^{\frac{3}{8}} [1 - B_2 u^{\frac{1}{2}}].$$

This is true for ordinary muzzle values of y or $\frac{u}{L}$. The part inside brackets, or $1 - B_2 u^{\frac{1}{2}}$, is very approximately true for the whole

length of bore. The part outside is true only for muzzle distances. If we substitute for $A_2u^{\frac{3}{8}}$, $M_2 Y_0^{\frac{1}{2}}$, the velocity formula will be very approximately true for the whole length of bore.

For any point, then, in the travel of the projectile inside a gun, $v = M_2 Y_0^{\frac{1}{2}} (1 - B_2u^{\frac{1}{2}})$, M_2 being determined by the condition that $M_2 = \dfrac{A_2u^{\frac{3}{8}}}{Y_0^{\frac{1}{2}}}$ at the muzzle of the gun.

Squaring, $v^2 = M_2^2 Y_0 (1 - B_2u^{\frac{1}{2}})^2$. Consequently, for the pressure at any point we have

$$P = \frac{m}{\omega}\,\frac{d(v^2)}{2du} = \frac{2p}{g\pi c^2}\,\frac{d(v^2)}{du}$$

$$= \left[(1 - B_2u^{\frac{1}{2}})^2\,\frac{M_2^2}{L}\,\frac{dY_0}{dy} - M_2^2 Y_0 (1 - B_2u^{\frac{1}{2}})\,\frac{B_2}{u^{\frac{1}{2}}}\right]\frac{2p}{g\pi c^2},$$

or $$P = \frac{2p}{g\pi c^2}\,M_2^2 (1 - B_2u^{\frac{1}{2}})\left[(1 - B_2u^{\frac{1}{2}})\,\frac{dY_0}{Ldy} - \frac{B_2Y_0}{u^{\frac{1}{2}}}\right].$$

This formula will give pressures similar to those already obtained. The pressures calculated by any of these different formulæ will determine a pressure curve, the area of which will necessarily agree exactly with the muzzle energy of the projectile, as determined from the corresponding velocity formula.

The pressure formula deduced from (27) gives pressures a little higher at the muzzle and correspondingly decreased at the breech of the gun. It is probably a little closer the truth than the first. As calculated by the first formula, the maximum effective pressure on the base of the projectile is 32,000 lbs. in the VIII-inch B. L. R., and 26,200 lbs. in the VI-inch B. L. R. (Dolphin's gun). The maximum pressure in the VIII-inch B. L. R. with 122 lbs. C_{82}, as measured by a crusher gauge, was 15.2 tons. For 125 lbs. of the same powder it should be 35,500 lbs. The difference between 35,500 and 32,000, or 3500 lbs., seems hardly large enough when we remember that the charge is one half the weight of the projectile, and that all of it is probably in motion at the instant of maximum pressure, with a mean velocity and mean acceleration equal probably at least to $\frac{1}{3}$ that of the projectile. The maximum effective pressure would then be in the neighborhood of 30,000 lbs. Likewise for the VI-inch B. L. R. (Dolphin). The recorded maximum pressure determined from the mean of 10 rounds in the VI-inch, Mark II. (which has a chamber very slightly larger than the Dolphin's gun), using $53\frac{1}{4}$ lbs. of C_{82} powder, was 13.9 tons. The pressure for 50 lbs. in the same gun

would then be 27,900 lbs., or, in the Dolphin's gun, 28,000 lbs. in round numbers. The difference, 1800 lbs., between this and the effective pressure, 26,200 lbs., as in the VIII-inch B. L. R., is probably about one half of what it should be. The recorded pressure in the South Boston gun was 12,100 lbs. This is lower than the calculated maximum effective pressure, which is 13,500 lbs. The ordinary empirical formulæ for maximum pressures, using the data furnished by the VI-inch B. L. R. (Mark II.), or the VIII-inch B. L. R., give in the S. B. gun a pressure on the breech-block of about 14,500 lbs.

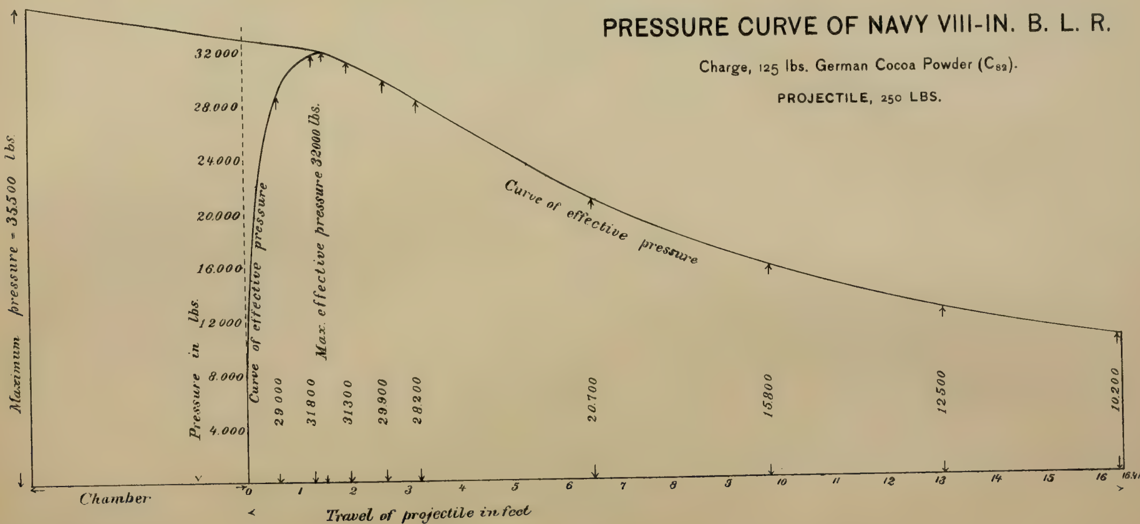
It is possible that the quantity n, assumed as 1.4 in calculating the tables in this paper, is not exact. Also that the velocity of combustion of powder does not vary exactly as the square root of the pressure. The character of the rifling and the form of the powder chamber, the forcing of the projectile, etc., also play a more or less important part. The volume of the solid residue of powder is not exactly equal to the volume of the powder. It may then be argued that the results obtained are certainly very fair. There is, however, no reason to suppose that the exact formula for velocity as deduced (19) is more accurate (or even as accurate) than the slightly empirical formula (15), obtained, in this paper, from it, and which has been demonstrated by a large number of firings to agree very closely with experiment.

In any gun, the pressure curve should be calculated from the velocity formula which gives the best actual results for velocity. The effect of rifling is to increase the subtractive term in the velocity formula as y increases, according to some power of y. It is possible then that the second term in brackets may vary not only as $y^{\frac{1}{2}}$, but in some cases even in excess of this power. To obtain the pressure upon the walls of the gun at any point, the pressure necessary to accelerate the rotation of the projectile and to overcome friction must be added to the effective pressure at the same point.

PRESSURE CURVE OF NAVY VIII-IN. B. L. R.

Charge, 125 lbs. German Cocoa Powder (C_{82}).

PROJECTILE, 250 LBS.



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

IGNITION OF EXPLOSIVE MIXTURES OF GASES BY BROKEN INCANDESCENT LAMPS.

EXPERIMENTS MADE AT THE TORPEDO STATION, NEWPORT, R. I.

BY LIEUTENANT HAMILTON HUTCHINS, U. S. N.

The behavior of incandescent lamps in explosive gases is of considerable importance in the present days of electric lighting. It is important as regards safety on board ship, and it is even more important in connection with lighting mines by electricity. I think heretofore it has been the popular opinion, at least in this country, that on breaking an incandescent lamp bulb in an explosive gas, the filament would be broken before the gas could become ignited and that thus there is no danger to be apprehended.

A great many experiments have been made by people at different times in connection with this subject, but most of them are incomplete, owing to the fact that they do not take into consideration the fact that the gases must be mixed in proportions known to be explosive.

In an extract from the *Electrical Review*, February 18, 1888, on the "possibility of ignition from incandescent lamp filaments," is quoted: "We *believe* that, under such conditions, the gas would be exploded in the event of the breakage of the lamp." This would imply that experiments were still wanting to settle this question.

I have been engaged at intervals during the past six months with experiments to determine "whether or not incandescent lights may under some circumstances be dangerous to ship lighting," and made the following report (January 20, 1888) to the Inspector of Ordnance in charge of the Torpedo Station:

Experiment No. 1.—By means of a station battery and a water voltameter a sufficient amount of hydrogen and oxygen was col-

lected to about fill an exercise gunpowder torpedo case. The fittings to the case were as follows: An entrance at the side to admit a steel rod for piercing the bulb, a window to ascertain whether or not the lamp was burning, and a wooden frame to hold the lamp, the latter being inserted at the lower end of the case, which was open and under water. The explosion of a mixture of hydrogen and oxygen being violent, the case was lashed down so it would not have to be held in position. A Swan lamp of 16 c. p. was used in this experiment, the carbon filament was raised to a white incandescence from a dynamo, and the lamp in its frame introduced into the case containing the explosive gas. The bulb was then pierced. The gas exploded immediately with considerable noise, completely shattering the lamp bulb but not bursting the tin case. The carbon filament remained intact, probably due to the fact that the glass bulb was shattered into an innumerable number of small pieces. From this experiment two points are evident:

1. That the inrush of gas does not break the Swan filament before the gas can become ignited; and

2. That in a highly explosive gas the breaking of an incandescent lamp would be dangerous, at least with a filament not less delicate than that in the Swan lamp.

Experiment No. 2.—Marsh gas is said to detonate when mixed with air in the proportion of one volume of the gas to seven and a half volumes of air. The gas mixed in the above proportions was collected in a case similar to that used in experiment No. 1. The same kind of lamp was used and the experiment conducted in a manner similar to the preceding. The gas did not explode. The filament was found to be broken, due of course to the flying pieces of glass.

Experiment No. 3.—Coal gas alone was used in this experiment, simply to observe the effect. The experiment was conducted in a manner similar to the preceding ones, except that a Maxim lamp was used. The result on piercing the bulb was that the filament continued to burn, the gas probably being decomposed, and carbon deposited on the filament in a manner similar to that in the "flashing test" in the manufacture of incandescent lamps.

Experiment No. 4.—In this experiment coal gas was used mixed with air in the proportion of one volume of the gas to six volumes of air. A Maxim lamp was used and the experiment conducted in a manner similar to the preceding ones, except that a pressure gauge

was used to make certain whether or not the gas exploded, for this gas being a weak explosive, the noise of the explosion might be faint.

On piercing the bulb, the filament not having been broken by the inrush of gas nor by flying pieces of glass, the lamp continued to burn for a few seconds; then, the required temperature being apparently reached, the gas exploded, making quite a noise. The tin case not being lashed down in this experiment, was lifted five or six feet in the air and the filament then broken from the shock of the explosion. It is considered unnecessary to experiment further with marsh gas, as the latter is even more explosive than coal gas.

As a result of these experiments it is clear that the incandescent filament (provided it is as tough as either the Swan or the Maxim filaments) coming in contact with either a highly explosive gas such as a mixture of hydrogen and oxygen, or a comparatively weak one such as coal gas and air in explosive proportions, will explode them.

I am of the opinion, therefore, that when explosive gases are allowed to collect on board ship from bad ventilation or other causes, incandescent lights such as were used in these experiments are dangerous to ship lighting.

Other experiments could no doubt be made that would be interesting and perhaps valuable in connection with this subject. For instance, it is claimed for the Edison lamp that the filament is always broken by the first inrush of gas. If this be true, there would appear to be more safety with the Edison lamp for ships' use.

In connection with the first experiment,* I would state that the precaution was taken to carefully solder the leads to the springs in the Swan socket, for otherwise an arc or spark might be formed which would explode the gas and that would be misleading.

Since the above experiments were made I received a communication from W. E. Peters, civil and mining engineer at Athens, Ohio, enclosing an extract from the Transactions of the "Mining Institute of Scotland," Vol. III, pp. 145–155. This extract describes an experiment made at Earnock Colliery, Hamilton, August 11, 1881, in the presence of Mr. Andrew Jamieson, C. E., Principal of the College of Science and Arts, and about 100 members of the Institute. The experiment was to ascertain whether Swan's lamp would explode gas if it were broken in a mixture of inflammable gas. "For this purpose a box 15 inches square and 2 feet deep was suspended from

* In the first experiment I am indebted to Ensign Denfeld, U. S. N., for his valuable assistance.

the roof enclosing a Swan lamp, and containing a pane of glass on one side, through which the lamp was seen burning. The box was filled with coal gas until it reached the explosive point, which was ascertained by the insertion into the box of a Davy lamp. The crucial step in the experiment was then taken, the glass globe within which the incandescence is carried on, *in vacuo*, being broken, when immediately the gas inside the box was ignited and exploded. This was taken as conclusive, as Mr. Jamieson has previously admitted, on the point as to the Swan lamp only being safe so long as it remains intact. The illuminating power of this lamp was about 15 candles."

This would seem to corroborate my experience so far as the Swan lamp is concerned, provided they took the precaution to connect the lamp leads so as to prevent by any possibility an arc or spark being formed at the springs in the base of the Swan socket which might explode the gas.

Experiments Made in the Physical Laboratory, U. S. Naval Academy, by Professor N. M. Terry, Ph.D., and Lieutenant T. B. Howard, U. S. N.

The socket of an Edison 16 c. p. lamp was fixed to a block in a cubical box of about one cubic foot capacity, so that when the lamp was inserted it would be near the centre of the box. Paper was pasted over the top of the box, and the mixtures, generally of coal gas and air in different proportions, were introduced through a stop-cock in the side of the box, the air being forced out through another stop-cock. After the air had been displaced by the mixed gases the current from the dynamo was turned on, and the light from the glowing lamp could be seen through the translucent paper cover. By means of a large wooden screw passing through one side of the box the lamp was pressed between the end of the screw and a block of wood on the opposite side until it broke. A loud explosion immediately followed, and the paper cover was torn and thrown about the room. The lamp was shattered and the carbon filament broken into pieces. As the lamp was burning safely in the explosive mixture until it was broken by the screw, it is evident that the gases were not ignited by any spark or arc across an imperfect contact in the socket or leading wires, but by the contact of the mixed gases with the glowing carbon. A fuller account of the experiments may be found in a report made to the Superintendent of the Naval Academy, December 8, 1887.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

APRIL, 1888.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XVII.

We are in receipt of a pamphlet entitled "The Graydon Dynamite Projectile High Explosive and Accelerated Cartridge," from which we learn that the experiments made at Sandy Hook, which were described in No. XVI of these Notes,† were carried out under the Graydon system.‡ The pamphlet contains three cuts showing the target before and after the experiments and one of the shells which struck "point on." The target, according to the cut, was a section of a monitor turret in service condition, lacking only the support which the completed cylinder gives. We should judge from the appearance of the shell, if the artist has represented it correctly, that the explosive did not undergo complete detonation.

Captain Zalinski having criticised the results of these experiments adversely, he was met by a letter from W. W. Dudley, general manager of the Graydon Dynamite Company, which was published in the Washington *Post* of February 27, 1888, and in which exceptions were taken to some of Zalinski's alleged statements. Captain Zalinski's reply to this appears in the Washington *Capital* of March 4, 1888, and the New York *Herald* of the same date. We have not

* As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

† Proc. Nav. Inst. 14, 156–158; 1888. ‡ Ibid. 13, 412–413; 1887.

seen the first two statements, but have been supplied with copies of the last two. In the *Capital* Captain Zalinski says:

"The Graydon system has thrown but very small charges of high explosives, and cannot throw very much larger ones successfully, 'with full powder charges.' It can hardly, therefore, be considered in the same category as the Pneumatic Torpedo Gun system, which has already thrown shell containing 100-pound charges of explosive gelatine and dynamite No. 1, and will, within a very few weeks, throw charges of 600 pounds.

"But as a proof of the substantial correctness of my statements, the following is given as a summary of the *last* Graydon experiments at Sandy Hook.

"Experimental firing with shells charged with dynamite by Graydon's method were made by the Ordnance Board, U. S. A., at Sandy Hook, on December 1, 1887, under supervision of Mr. Graydon, to obtain penetration of armor. A delayed action percussion fuze was used. Seven shots were fired from a 7-inch M. L. rifle; weight of charge 23 pounds, weight of loaded shell 122 pounds, weight of dynamite in shell about 2¼ pounds. The target was a section of a wrought iron turret 14 inches thick, composed of two 7-inch layers which had been considerably damaged in former experiments. It was placed 100 yards from the gun. The first shot fired, without fuze, exploded violently upon striking target. All the other shells were provided with fuzes; the second deepened the indentation about 2 inches, and the third about 4 inches. The fourth and fifth shots were fired at a wooden target about a mile distant; the fourth burst prematurely in the air, the fifth burst upon striking. The sixth and seventh shots were fired at sea; the flight of the sixth was very irregular, it probably failed to take the grooves. It did not burst upon striking the water. The seventh burst prematurely in the air. To demonstrate the safety in handling shots were fired from a Springfield rifle at a can filled with the prepared dynamite. It blew up at the third shot.

"In the experiments preceding the ones of which very partial and incomplete extracts of the board are given in Graydon's pamphlet, a gun *was burst* in the attempt to fire one of the Graydon shells. This can be substantiated by reference to official reports. There is also quite authentic information that at *least* one gun has been burst by Graydon in European experiments.

"It will be noted that in all the quotations made from reports of

boards no mention is made of the fact that a gun had been burst at Sandy Hook. This may, however, appear to be a very trifling matter. It may be well to analyze the recent Sandy Hook experiments, upon which so much stress is laid, and see what has been accomplished. The weight of shell thrown was 122 pounds. The charge of dynamite claimed was $2\frac{2}{3}$ pounds. There is reason to suppose that the charge of *dynamite* was really less, but it is too small a matter to discuss further. But the dynamite thrown was only a 60 per cent dynamite. Now, in speaking of dynamite for military purposes, No. 1 dynamite, containing 75 per cent of nitro-glycerine, is supposed to be referred to. The 60 per cent dynamite is less effective by 20 per cent than the No. 1 dynamite, and also much less sensitive to shock. Being tested in cold weather (December), may also be a factor to consider, in view of the ease with which it congeals, and its reduced sensitiveness and efficacy when in a congealed state. This charge of $2\frac{2}{3}$ pounds is a trifle more than 2 per cent of the total weight of the shell. Whatever its effect might be if the shell had really penetrated armor, its effect would certainly be nil as a *torpedo.* On the other hand, the shell of the Pneumatic Torpedo Gun carries a charge of the highest grade of high explosives of from 60 per cent to 200 per cent of the weight of the shell. In other words, the charges its shell will convey are from 100 pounds up to 600 pounds of explosive gelatine. Comparing simply the charges actually thrown, we have a record of shells fired carrying a charge of 100 pounds of explosive gelatine, equivalent to at least 166 pounds of Mr. Graydon's 60 per cent dynamite, or more than sixty times as much. The larger charges thrown by the Pneumatic Torpedo Gun must be effective for torpedo action against the under-water hull, and this is the main point claimed. But, if properly exploded, they will not be innocuous when striking the over-water hull.

"It is obvious that Mr. Graydon has done nothing to approach this, and cannot, therefore, claim to come within the same field. The full official reports will show that several of the Graydon shells *did* burst near the muzzle and some distance therefrom *whilst in the air.* Let us now examine the claims as to penetration of the target and the character of the injuries done thereto. The target, as stated by Graydon, consisted of two layers of 7-inch wrought iron plates bolted together. This is very far, in its resisting capabilities, from a 14-inch plate. The illustrated pamphlet, published also by Graydon, shows that these, which were bent in a semicircular form, simply stood,

unsupported at front or rear, on some planking. They weighed, at most, 120 tons. The Graydon shell, weighing 122 pounds, if fired 'with full powder charges,' should have attained a velocity of not less than 1300 feet per second. This should give an energy of at least 1400 tons. The 7-inch shell, *without any bursting charge*, should have obtained a *penetration* of at *least nine* inches. The utmost penetration shown by the official report is only *eight* inches, and this penetration was produced by hitting in a spot where, at some previous experiments, the target had been indented from one to *three* inches. It may be well to state here that this same target had been very considerably injured by firing of shell other than the Graydon in previous experiments.

"The *penetration* produced, it is seen, is less than that due to a blank shell. As the target weighed only 120 tons and was totally unsupported against a blow of 1400 foot tons of energy, due to the shell, unaided by the explosive, it would have been very easily racked and shaken up by the first round, so that the bolts assembling the various plates would have been disrupted and the plates separated. They would not, in this condition, present much more resistance than that due to *a single unsupported 7-inch* plate. It is to be noted, also, that this plate has numerous very large bolt holes in it, which would not exist in modern armor plates; these would determine lines of weakness in the plates already well battered by previous fires.

"The shells used were probably not less than 2½ calibers long, and therefore about 17 inches in length. The maximum penetration *claimed* was only 8 inches. It will thus be seen that hardly more than the ogival point of the shell had entered the plate before explosion, and thus the explosion had taken place practically *outside* of the target. 'Penetration before explosion' can hardly be substantiated by these results, even when a portion of the indentation had not been made at a *previous* fire. Especially is this the case in view of the fact that the *blank* shell would have produced a *greater* indentation than was actually claimed for the *loaded* shell.

"The racking effect of a blow of 1400 foot tons of energy on an unsupported iron target, weighing only 120 tons, would easily snap the 1¼-inch bolts by which the top or cover plates were attached to the vertical target. The explosion of the charge ensuing probably *after* this blow had been delivered might very readily shake and lift this, weighing only 15 tons, and deposit it a few feet from the vertical

target, particularly as it is seen, from the illustrated Graydon pamphlet, that there was a marked over-hang of the turret cover.

"I will concede that a shell charged with high explosives will, in itself, produce but little injury to an iron target, unless properly exploded from the rear end, and not by simple impact. Although Graydon claimed that no explosion would ensue if his shell did not carry his fuze, explosion *did* take place in his first fire, where the shell *was* unfuzed.

"I should be pleased to think that a charge of 2½ pounds of 60 per cent dynamite could really perform the injury to a well supported target when exploding, as did the Graydon shell, on the unsupported target practically outside of the plates; I should feel more sanguine than ever of the results which a 600-pound charge of camphorated explosive gelatine would produce on striking even the heaviest armor, although this is not the objective target of the pneumatic torpedo shell.

"To summarize: The official report will show that Graydon had burst at least one gun at Sandy Hook; that he had *not penetrated* with his shell, *before explosion*, to an extent as great as would have been accomplished with a blank shell; that the injury done to the unsupported and already injured target was but little more than would have been accomplished by any equal number of rounds with similar powder gun shell; that *several* Graydon shell *did burst prematurely in the air without impact on any target;* that the percentage of the weight of high explosive thrown is insignificant when compared with the total weight of the projectile; that the sum total of the results obtained would certainly not encourage the Ordnance Department of the Army or Navy to permit the Graydon shells to be fired from their best modern high-power guns, which alone can give requisite penetration, pure and simple, against modern armor. Neither would the results as to *safety* warrant the gunners standing by the guns when fired, or make it permissible to fire these shells over the heads of troops or outlying works of the defense.

"The questions raised regarding the report of the Naval Board on the Pneumatic Torpedo Gun may be discussed at some future time and before the proper authorities.

"Very much is conceded therein without qualification, particularly as to its accuracy, safety, and applicability in harbor defense. Personally, I desire nothing better than to be able, when the Pneumatic Dynamite Torpedo Gunboat is completed, to attack an armored

vessel, of the strongest construction that modern ingenuity can give both to the under-water and over-water hull.

"For purposes of comparison of the relative *chances* of hitting, and of *efficiency* when hitting, I would have, at the same time, an attack on the target by ships carrying high-power powder guns and using Graydon's shells (if they will dare to use them) or any other kind of shells, and by torpedo boats carrying Whitehead, Howell or any other kind of torpedoes. Such a trial should simulate service conditions as nearly as possible, the attacking force at least to be in motion at full speed. If the sea is rough, so much more thoroughly will be the question of the relative *chances* of obtaining results be settled.

"The efficiency of the Pneumatic Torpedo Gun when on a fixed platform has been settled by actual trials, and is very fully conceded in the report of the board referred to by the general manager. It does not depend upon the firing of a very few shells carrying insignificant charges, nor does it have a record which would render it prudent for the gunners to get within a bomb-proof when it is fired."

The *Army and Navy Register*, March 24, 1888, states that Mr. Graydon recently filed with the Secretary of War charges against Captain Zalinski of conduct unbecoming an officer and gentleman, in that he is said to have publicly made unjust reflections upon the Graydon dynamite gun. Lieutenant Graydon asked that a court-martial be ordered for the trial of Captain Zalinski on the charges, and that the members of the Army Board of Ordnance be summoned as witnesses. Assistant Secretary Benet declined to entertain the request for a court-martial, on the ground that if Graydon's business interests have been damaged by statements made by Captain Zalinski, a military tribunal could afford him no relief. From the same journal, March 17, 1888, we learn that the House Military Committee has determined on a favorable report of the bill appropriating $10,000 for the conduct of experiments with Lieutenant Graydon's dynamite shells, and recommended that one of the old monitors be placed at his disposal for use as a target for these projectiles.

In discussing Captain Zalinski's paper on "The Naval Uses of the Pneumatic Torpedo Gun,"* we have said: "In considering the effect of the pneumatic gun projectile, it becomes evident, from the material of which it is made, the lightness of its walls, and the low velocity

* Proc. Nav. Inst. 14, 44; 1888.

with which it is propelled, that penetration is impossible. In fact, Captain Zalinski states that the shell will be crushed on impact; then the conditions which prevail tend to produce a low degree of efficiency. But to meet this criticism Captain Zalinski has devised a most ingenious hypothesis. He holds that the inertia of the explosive will act as a tamping or as a confining envelope. *This hypothesis is one which easily admits of being experimentally tested, and it is much to be regretted if Captain Zalinski has failed to do this.*"

In reply to this Captain Zalinski says:* "Had Professor Munroe carefully read some of the papers previously published on the gun experiments, and portions of which he had republished in the U. S. Naval Institute Proceedings, he would have seen that the value of a tamped charge as compared to an untamped charge had been fully recognized, and that definite experiments had been tried proving this. These experiments were made by explosions of charges suspended against iron plates, and by firing the charges from the pneumatic gun against the iron plates. The Professor misapprehends as to the arrangement of the shell. It is not intended that the part containing the charge is to be crushed on impact before explosion can take place. The electrical arrangements are such as to insure explosion before the body of the shell can be crushed. In this way the tamping effect of the encasing shell is obtained, as well as from the initial detonation taking place at the rear of the charge."

Such résumés and notices as we have made of papers relating to the gun experiments will be found in **11**, 285–293, 767–769; **12**, 616–617, and **13**, 567–573. Lest we have inadvertently done Captain Zalinski an injustice we have again carefully reviewed the sources from which these abstracts were taken, and the only experiments of the kind which we find described are in "The Pneumatic Dynamite Torpedo Gun," published in the *Jour. Mil. Serv. Inst.* 8, 1–35; 1887. In the reprint which we possess we find on pages 9 and 10: "As soon as a suitable battery had been selected, arrangements were made to try experiments upon iron plates to determine the best details of arrangement of the charge and of fuze. The following experiments were tried:

"An iron target was constructed of plates of the English ship Nankin, sunk in the harbor and being raised by the Engineer Department. The plates were supported against the interior parade wall, and the gun was placed outside of the fort, at the sally-port, 60 yards

*Loc. cit. **14**, 53; 1888.

from the target. A blank shell charged with sand, total weight 30 pounds, was fired. It penetrated three plates, aggregating 2.5 inches. A similar shell, charged with dynamite, having no fuze, intended to explode on impact, penetrated only a single plate, and its effect was actually *less* than the blank shot previously fired. Another shell fired with a detonating fuze in the front of the charge did but little more damage. An electrical fuze was then arranged so that the circuit should be closed when the body of the shell was one-eighth inch from the target. The primer was placed in the rear part of the charge. To further insure against premature explosion by simple impact, a thin layer of cotton waste was placed in front of the shell. The resulting explosion was the most effective produced; the six plates of the target, aggregating 4.5 inches, being broken through and indented in nearly a circular area of about 18 inches diameter. The stone wall in the rear was also somewhat broken by the shock.

"It was evident from the results obtained that the effect to be produced by the explosion of the dynamite shell would not be limited to simple puncturing of a target, but that it would produce cracks and breaks at points distant from the point of impact. This was shown in some experiments upon the stern-post of the Nankin, a forging about 5 inches by 8 inches cross-section. Charges of 3 pounds were exploded upon it. They simply indented the piece at the point of placement, but broke pieces of 2 feet in length at the extremities 6 feet and 8 feet distant, and produced large cracks at other points."

Again, pages 19 and 20, he says: "An experiment tried by Commander Folger, U. S. Navy, is often quoted. In this a charge of 100 pounds of dynamite was suspended against an iron target consisting of eleven one-inch plates, strongly bolted together, and backed by 20 inches of oak well braced. The result was an indentation of only about 2 inches, extending over an area of two feet. From this the conclusions are published, 'that a modern armor-clad will not receive material injury by the explosion in superficial contact with iron over-water plating of very large charges of dynamite.' The superficial contact of the charge, as exploded, did not to my mind represent the conditions at the instant of explosion of a shell from the pneumatic gun. The element of tamping was here entirely lacking. To test this matter in a small way, the following experiment was tried:* A cartridge of 8 ounces of dynamite was suspended in 'superficial contact' with an iron plate three quarters of an inch thick, and there

*Vide Proc. Nav. Inst. 13, 570; 1887.

exploded. The result was a simple indentation of the plate. A charge of 8 ounces was again suspended against the plate, but over it was loosely suspended a piece of angle iron open at both ends, and of such size that the inscribed circle between its sides and the plate was less than the cross section of the charge, which was cylindrical. Thus there was no direct pressure against the cartridge. Yet a large elliptical hole was blown through the plate considerably longer and broader than the cartridge. This experiment was repeated with almost identical results. When two plates were placed together, a hole was blown through *both* plates."

Among the appendixes to the *Annual Report of the Chief of Ordnance, U. S. A.*, soon to be published, is one prepared by Major George W. McKee, on "The Present Status of Dynamite as an Explosive for Shells." Prefacing it with a brief history of the discovery and use of nitro-glycerine, he says: "Nobel's explosive gelatine or blasting dynamite has been used in this country by United States officers, to the entire demonstration of the fact that this high explosive, contained in a shell as a bursting charge, might be fired from a gun. The ordinary blasting dynamite made by the company (some of it experimentally modified by about three per cent of camphor) was used, and enough shells were thrown from the bores of the old mutilated guns used in the experiment to demonstrate the fact that the dynamite could be projected in shells from an 8-inch rifle gun with a 40-pound charge of powder. The great chemist, Nobel, never, perhaps, thought of applying his invention to this delicate test; but his powerful and wonderful gelatine, made only to be detonated in mines and the like, stood in several instances the tremendous initial shock of the gunpowder, and, by the aid of the rectangular diaphragms devised by Captain Whipple, of the Ordnance Department, stood, what is thought to be equally dangerous, the heat developed by the angular velocity. If the gelatine had been especially undertaken by these chemists for a military and not an industrial agent, and enough time and means had been at hand to perfect the diaphragm, it is believed all of the shells would then have become, as they will be in future, high-explosive batteries, projected with as much safety as though they had been charged with black gunpowder."

Major McKee, in reviewing various experiments that have been conducted under the direction of the Ordnance Department, speaks

of them as follows. Of the method exhibited by Mr. Snyder* he says: "He did fairly well with some of his firing at the Hook and on the Potomac, near Washington, D. C., and, as he is a man of inventive talent and an American, no one wishes him more success in his future experiments with dynamite than the men who were delegated by the Government to supervise and report upon those he originally undertook." In the experiments with shells loaded with dynamite, conducted by Brevet Brigadier-General John C. Kelton, at Point Lobos, near San Francisco, Cal., in March, 1885, no specially camphorated or otherwise prepared explosive was used, but the shells were charged with the crude blasting industrial dynamite. Three rounds were fired from a 3-inch wrought-iron rifled gun, shells with 200 grams of dynamite, and a variable charge of projection. The target was a large rock at 157 yards distance. In the first two rounds the shell burst into innumerable pieces on striking the rock, but in the third it burst within the piece. Colonel Kelton considered this experiment as very satisfactory, since it demonstrated the possibility of employing dynamite in shells, as well as the great strength of this great explosive; and he estimates that for the effective use of the artifices, which, according to him, is to destroy ships, one half the length of the projectile is the penetration needed, requiring 0.001 of a second, and he expects it will be successful.

After describing some experiments at Sandy Hook in 1883, Major McKee sums up the results as follows:

"As detailed in the records, three shells were fired with fulminate of mercury fuzes. The fulminate was too sensitive to stand the shock, and it was found afterwards that the gelatine needed no detonator.

"Although the tests made were very few, it would nevertheless appear from them—

"1. That the shells explode after clearing the muzzle, and therefore the detonation of the gelatine is due to some cause other than the shock of discharge—very possibly the heat generated by angular velocity.

"2. This is corroborated by the fact that one shell passed through a 2-inch board target without explosion.

"3. The gelatine used in these tests not being camphorated renders it highly probable that a certain percentage of camphor added would

* Proc. Nav. Inst. 12, 617; 1886, and 13, 411; 1887.

establish a compound which could be fired successfully in a specially constructed shell.

"4. The gelatine does not require a fuze or detonator of any kind.

"5. It is believed the shell which destroyed the 3.2-inch breech-loading gun broke from the shock of discharge, or admission of powder gas, and thus detonated the gelatine."

In the summer of 1884 the Ordnance Board fired four cast-iron screw shells from an 8-inch muzzle-loading rifle, using 40 pounds of powder in the gun, and from 5 to 8 pounds of gelatine in the shells at each discharge. The gun was mounted on a cradle and directed at a target 383 feet distant. One of the shells burst at or near the muzzle with little comparative violence. The other three reached the target, penetrated about seven inches, and detonated from the shock. These trials led to the making of six steel shells, three of them being cast and three forged. Analysis of the facts connected with these experiments shows—

"1. That the 3-inch shells designed for gunpowder charge, when loaded with Hill's explosive gelatine three months old, all cleared the gun without injuring it in the slightest.

"2. That the shells, having to be charged through the fuze holes with the dynamite, were necessarily packed loosely, thus subjecting the charge to the powerful action of angular velocity.

"3. That in the trials made with the 3.2-inch, two Butler shells charged with black gunpowder broke up 'at or near the muzzle'; while of the two Butler shells charged with Nobel's gelatine, or dynamite, one broke up 'at or near the muzzle,' and the other reached the target and exploded on impact.

"4. That in the trials made with the same 3.2-inch gun, using thin Hotchkiss shrapnel cases, charged with Nobel's dynamite, or gelatine, all cleared the gun in safety (one reaching the target after passing through two-inch boards) with the exception of one, which the Board reported on as follows: 'It either broke from the shock of discharge or admitted powder gas.'

"5. That all the trials with the 8-inch shells charged with fresh Nobel's dynamite, or gelatine, were successful, three of the shells detonating at the target, and one only exploding at or near the muzzle; that the gelatine used when the premature explosion took place was sixteen months on hand in this country after crossing the ocean, and therefore not such as was recommended by General Abbot, or contemplated by the Board."

Major McKee's conclusions are as follows: that the United States officers undertaking the investigation of this subject were necessarily compelled to institute their inquiries *de novo*. All foreign information was so meagre, so unsatisfactory, and so shrouded in mystery, in accordance, doubtless, with the policy of the European governments, that it was seen, after careful investigation, that all trustworthy knowledge would have to be gleaned by Americans through experience. In obtaining this experience, devices have been experimented with, invented by Mr. Snyder, who presented several plans; Mr. C. P. Winslow, with a nitro-glycerine shell, in which the glycerine and combined nitric and sulphuric acids are placed in separate glass vessels within the shells; Mr. Garrick, with a mortar and projectile for nitro-glycerine; Mr. D. P. Hill, with an 8-inch explosive gelatine shell; Mr. Stevens, with a double shell for high explosives; Mr. Graydon, with a shell containing the dynamite in capsules; Mr. Taylor, who brought his own gun and attempted to use dynamite as a propulsive charge; and Mr. Smolianoff, experiments with whose gun were made as late as last October.

In all these trials, Major McKee said, as to the practicability of using dynamite as a shell explosive, that it was well understood by the officers undertaking them that the crude blasting compound of industry, which was the only available explosive attainable, was not the eventual product of chemistry which would satisfactorily answer this purpose. It was known that great improvements had been made in the dynamites of all kinds, especially in the blasting dynamite or gelatine of Nobel, and that these compounds presented in transportation by all modern conveyances, and in all mining and other industrial works, as much, if not greater, safety than the black war, sporting, and the blasting gunpowders of commerce. With this status of dynamite apparent, it was seen that the time had arrived for military men in the United States to begin with it as a shell explosive, with some possibility of success. When it was demonstrated that the freshly prepared crude commercial dynamite might be fired in a shell from an 8-inch gun with a charge of forty pounds of black gunpowder, the only question that then remained was as to the stability and reliability of the compound through age. And when, after sixteen months' storage, it appeared to be more sensitive to shock, the Ordnance Board recommended that no more experiments be made with it until it was further camphorated, or otherwise treated by competent chemists. And it was ascertained further, in these few and inexpen-

sive tests, that the heat developed by the angular velocity was a more potent factor in detonating the dynamite than was the shock of discharge. It has been seen, also, that, since the comparatively recent discovery of nitro-glycerine, its development has been rapid in the protean forms of dynamite. In Europe experiments are being constantly conducted to perfect this agent, and doubtless they will succeed. Even now they claim in France and Germany to have perfected melinite and helphonite (?), compounds probably of nitro-glycerine and some of the ethers (sic). In Russia they also announce some new improvements that are not known here. But in the near future there is every probability that the problem will be solved in this country.—*Science* **11**, 153, 154; March 30, 1888.

The surgeons who examined the bodies of the soldiers killed by the explosion of melinite at Belfort,* report to the French Chirurgical Society that of the seventeen men hit only six lived. The bodies of the slain, it is said, were literally torn into shreds, and it is the belief of Dr. Tachard and his assistants that much of the substance exploded only after entering the bodies, or, in other words, that melinite as now compounded explodes at different periods, some early, some late; the first bursting the shell into fragments, and the latter adhering to these fragments, exploding when driven home. They remarked on the absence of burns and of poisoning. The bodies of the wounded were found to be tatooed as if with explosive dust.—*Army and Navy Jour.* 25, 621; Feb. 25, 1888.

On November 3, 1887, Dr. S. H. Emmens made some public experiments at his home on Prospect Avenue and One Hundred and Sixty-fifth Street, N. Y., to demonstrate the qualities of his new explosive, "Emmensite." "The explosive is composed of two cheap and easily obtained materials; one is an extract from coal, and the other a mineral substance. The mixture may be pounded in a mortar, and neither ingredient separately shows any trace of an explosive nature. Another valuable quality which is claimed for emmensite is that it may be melted and fused into any shape, as a solid block, or may be granulated in various sizes; consequently, it may be used either as a high or low explosive. According to Dr. Emmens' computation, it can exert a pressure of 283 tons to the square inch, the next highest pressure being exerted by pure nitro-glycerine, 264 tons. The speed

* Proc. Nav. Inst. 13, 581; 1887.

of explosion is greater than that of any other practicable explosive, except fulminate of mercury. When used in a compact form, its highest possibilities of speed are obtained, and it is then suitable as a blasting agent. When manufactured in the form of powder, the rapidity of explosion is lessened in proportion to the coarseness of the grains, and it may then be employed in firearms. To-day a 32 caliber Smith & Wesson was fired from a distance of 6 feet at an iron plate $\frac{1}{16}$ of an inch thick. With four grains of emmensite the ball nearly pierced the plate, while with ten grains of powder the ball made only an indentation. A leaden hemisphere was placed on a rock; upon this were placed, successively, one ounce cartridges of gunpowder, explosive gelatine, dynamite, and emmensite. While the other explosives bent the lead, it was shattered by the emmensite. An iron plate 6 inches square was then suspended from the branch of a tree. A one-ounce dynamite cartridge placed on the plate simply bent it; a cartridge of explosive gelatine almost broke it; while the same amount of emmensite made a hole through the plate as large as a man's fist. Then, to show that the explosive would strike upward as well as downward, a cartridge was suspended and a leaden hemisphere was placed over it. After the explosion the lead was found to be not only shattered on the under side, but on its upper side also. The explanation is that the explosion took place with such rapidity as to force the gases through the pores of the lead, a thing which happens when the outer plates of a piece of artillery are injured and the inner plates remain unaffected by the shock. A piece of emmensite was immersed in a barrel of water for 1½ minutes and then exploded easily. Experiments were also given showing the value of the invention for pyrotechnical purposes. In its ordinary state, emmensite is a yellow powder and is a powerful dye, and the hair and beard of those handling it have become of a brilliant blood red."—*Boston Herald*, Nov. 4, 1887.

At the session of the French Academy of Sciences for December 12, 1887, Professor Berthelot presented a paper on the "Different Modes of Explosive Decomposition of Picric Acid and the Nitro-Compounds." After noticing the general belief which has existed regarding the explosiveness of picric acid, and alluding to Colonel Majendie's report* on the recent accidental explosion in England, he described the following experiments. When a notable quantity of

* Proc. Nav. Inst. 14, 149; 1888.

picric acid is heated in an open flask or capsule, it first melts and then volatilizes, giving out fumes which burn with a smoky flame, but no explosion takes place. When, however, a test tube about 25 to 30 millimeters in diameter is heated over a gas jet so as to produce a visible red, but without melting the glass or deforming the tube, on dropping into it some few milligrams of the acid, in crystals, a sharp detonation occurs, attended with a bright white light and the characteristic noise. When the experiment is performed in nitrogen gas, a few flakes of carbon are deposited; in ordinary air the result is the same, but no carbon is left. On increasing the quantity of picric acid, without, however, exceeding a few centigrams, the addition may cool the bottom of the tube sufficiently to prevent immediate detonation, but the substance is at once volatilized, and an explosion, attended with flame occupying a great part of the tube, occurs. This explosion is not so sharp as the more local detonation, and more carbon is apparently deposited. An explosion of this nature may be produced with a few milligrams of material, by using a glass tube coated with the carbon of a previous explosion. With a decigram of the acid and a fresh tube, the reaction will be slower still, yet a series of deflagrations with red flame will be observed, while the vapor will catch fire at the mouth of the tube. Finally, with large quantities the acid is decomposed, there being abundant fumes and partial volatilization without deflagration. Other nitrogenized bodies, less rich in oxygen than picric acid, such as the mono- and dinitrobenzenes and the nitro-naphthalenes, were experimented with and afforded similar results, thus leading to the conclusion that the mode of decomposition of all these nitro-substitution compounds depends on the initial temperature of decomposition.

Respecting picric acid more especially, M. Berthelot's conclusions are as follows: Should a nitro-compound, such as picric acid, while burning in large masses, happen to heat the sides of the containing enclosure to a degree sufficient to induce incipient deflagration, the deflagration might contribute to further increase the temperature of the enclosure, and the phenomenon might occasionally be transformed into a detonation. It would even suffice that the detonation should occur in an isolated point, either during a fire or owing to the local overheating of a boiler or apparatus, to enable it to originate the explosive wave and propagate itself by influence throughout the whole mass, causing a general explosion.—*Comptes Rendus* **105**, 1159–1162; Dec. 12, 1887.

Picric acid, picrates, and mixtures of picric acid with certain other substances, being "under certain conditions specially dangerous to life and property by reason of their explosive properties," an Order in Council has been issued in Great Britain under the provisions of the Explosives Act, 1875, declaring:

"(1) Picric acid when in process of manufacture or storage shall (for whatever purpose used or manufactured) be deemed to be an explosive within the meaning of the said Act for all the purposes of the said Act, subject to the exceptions following: (*a*) Picric acid when wholly in solution shall be exempt from being deemed to be an explosive within the said Act; and (*b*) picric acid which does not fall within the exemption above set forth, but which is being manufactured or stored in a factory, building, or place exclusively appropriated to the manufacture or storage of picric acid, and in such manner as effectually to prevent any picric acid from coming into contact (whether under the action of fire or otherwise) with any basic metallic oxide or oxidizing agent, or other substance capable of forming with picric acid an explosive mixture or explosive compound, or with any detonator or other article capable of exploding picric acid, or with any fire or light capable of igniting picric acid, shall be exempt from being deemed to be an explosive within the said Act. (2) Picrates and mixtures of picric acid with any basic metallic oxide, or any oxidizing agent, or with any other substance capable of forming with picric acid an explosive mixture, or any explosive compound (for whatever purpose used or manufactured), shall be deemed to be an explosive within the meaning of the said Act for all the purposes of the said Act, unless such picrates or mixtures be wholly in solution."—*Jour. Soc. Chem. Ind.* **7**, 48; Jan. 31, 1888.

Fleck states in the *Chem. Centr.* p. 99, 1887, that if a solution of picric acid is evaporated in a porcelain dish, the residue then being moistened with a 10 per cent solution of hydrochloric acid, a small piece of pure zinc being added to this and the whole allowed to remain in the cold for some hours, a fine blue color is developed. A solution of dinitrocresol (Victoria Yellow) treated in the same way yields a bright blood-red color. The original solutions are best made by extracting with alcohol.—*Jour. of Anal. Chem.* **2**, 120; 1888.

In a lecture delivered before the Aldershot Military Society, February 2, 1888, by Sir Henry Halford, on the new magazine gun

recommended for adoption by the British service, he says of the explosive to be used: "We take Curtis and Harvey No. 6 for instance, but that requires a great deal of room, and the Swiss have managed to compress their powder in such a way that they can put 70 grains into the space occupied by 55 of our powder. It is quite true that powders for small arms are in their infancy. We hear of nitrate powder, smokeless powder which will be suitable and accurate for rifles. So far I believe it has not been used with success. The French find it will not keep. For use it is impossible to take a powder that will not keep for at least ten years. If we adopt a powder without adequate time being taken to test its storage capabilities, it will be a bad thing for the country. But we can take Rubini powder and work with that, and meanwhile make experiments with these nitrate powders and see if anything can be done towards getting a smokeless powder for the future."—*Army and Navy Jour.* **25**, 601; Feb. 25, 1888.

Prof. W. Mattieu Williams infers, from an examination of Count Rumford's "Essay on Gunpowder," that he produced solid carbonic acid* in the course of his experiments on the explosive force of that composition. In an experiment with a confined cylinder the Count observed "an extremely white powder, resembling very light white ashes, but which almost instantaneously changed to the most perfect black color upon being exposed to the air." Prof. Williams supposes that this white evanescent ash-like deposit was solid carbonic acid. The change to black mentioned by Rumford was caused by the instantaneous evaporation of the acid which revealed the ordinary black deposit of gunpowder beneath it. The pressure under which the experiment was conducted was 9431 atmospheres, which is abundantly sufficient to effect the solidification of carbonic acid.—*Pop. Sci. Month.* **29**, 718; 1886.

The Royal Prussian Fire-Damp Commission has carried out a series of experiments in the Royal coal-mine near Neunkirchen, the results of which go far to confirm Mr. W. Galloway's † theory of the agency of coal-dust alone, and in conjunction with fire-damp, in propagating explosions in mines. At the mine in question is a blower for fire-damp at a depth of 131 yards below the surface, which gives off 0.9 cubic feet of gas per minute. For the experiments cannon were planted at the closed end of a horizontal gallery 167 feet long, having

* Proc. Nav. Inst. **12**, 621–623; 1886. † Ibid. **12**, 429; 1886.

a branch 33 feet long, starting at a distance of 93 feet from its closed end. The branch gallery was closed at both ends with two-inch planking. One gun was fired when the gallery was free from fire-damp and from coal-dust; the flame of the shot was a little over 13 feet long. In a second experiment the floor of the gallery was strewed with coal-dust 1.17 inches thick for a length of 65 feet. The shot gave rise to a loud detonation, and the resulting flame filled the gallery to a distance of 88½ feet. The inner planking of the branch gallery was broken. In the third experiment the gallery floor was strewed with coal-dust for a length of 130 feet. The flame traversed the whole length of the gallery with great velocity, and came out at the open end to a distance of 16 feet, or 183 feet in all. It also emerged from the branch gallery to a distance of several yards. The outer partition of this gallery was broken into small fragments. For the fourth experiment, the partitions in the branch gallery were replaced, coal-dust was strewed on the floor for a distance of 65 feet, and a volume of 35¼ cubic feet of fire-damp was introduced and completely diffused. The firing of the shot produced a flame 190 feet long, accompanied by a report like a thunder-clap. The inner brettice of the branch gallery was broken and drawn several yards into the main gallery, but the outer one remained intact. The incidental effects of the last two shots also indicated how tremendous a force had been let loose when coal-dust formed one of the elements of the explosion. These experiments were typical of two hundred similar ones that had been made with from one to seven guns, all marked by results sustaining the coal-dust theory.—*Pop. Sci. Month.* **27**, 714; 1885.

We are indebted to Sir Frederick Abel for a copy of his very valuable paper on "Accidents in Mines," which is reprinted, together with the discussion, as a pamphlet of some 200 pages, from the *Proc. Inst. Civ. Eng.* for 1886–1888, and from which we propose to abstract for a later number of these Notes.

A striking new experiment, exhibiting the explosive nature of "Nitrogen Chloride," is described by Prof. Victor Meyer in the *Ber. Chem. Gesell.* **21**, 26–28; 1888. A few drops of yellow chloride were prepared in the usual manner by inverting an exceptionally thin flask filled with chlorine gas in a leaden dish containing a solution of ammonium chloride. Instead, however, of gently agitating the apparatus so as to cause the drops to fall into a smaller leaden capsule placed beneath the mouth of the flask, they were allowed to float freely

upon the surface. The whole apparatus was then enclosed in a cover-box fitted with stout plate-glass sides, through the top of which was passed a bent pipette, turning up below just under the mouth of the flask, and connected outside with a dropping funnel containing ammonium chloride solution and a few drops of turpentine. When sufficient nitrogen chloride had collected, the tap of the funnel was carefully turned so as to allow a little turpentine to slowly rise in the flask. After a moment or two it reached the surface and mingled with the nitrogen chloride, causing a brilliant flash of light and a loud explosion, which Prof. Meyer likens to a thunder-clap, so much more powerful is the detonation in a confined space. The flask, of course, was shattered, not into powder, but into tolerably large fragments; the plate-glass box, however, even after many repetitions of the experiment, remained intact, a small door on the side away from the observers having been left ajar so as to prevent any notable increase of pressure. Curiously, the nitrogen chloride never entirely exploded; a part remained in the distorted leaden dish and maintained an incessant fusilade for more than a minute.

At the last meeting of the Göttingen Chemical Society, Dr. Gattermann read a preliminary note upon his recent researches on "Nitrogen Chloride." From his analyses it appears pretty clear that the yellow liquid is a mixture of at least two distinct chlorides, which he has hopes of being able to separate. During the course of his experiments the reason of its capricious behavior, which has been the cause of so many painful accidents in the past, was happily discovered. It is decomposed by the actinic rays of light, being rapidly acted upon by sunlight with periodic spontaneous explosions, and being at once fired by exposure to the rays of burning magnesium. Hence the further study of this subject must be carried on in the dark room.—*Nature* 37, 350; Feb. 9, 1888.

These results of Gattermann's with nitrogen chloride recall those obtained by Guyard with nitrogen iodide, *Bull. Soc. Chim.* **41**, [2] 12; Jan. 1884. He found the action of light on this amide so marked that he proposed to use the phenomenon for photometric purposes.

Through the courtesy of Dr. Wolcott Gibbs we learn that in 1843 or 1844, while Dr. John Torrey was exhibiting to his class at the College of Physicians and Surgeons of New York the oxidizing effect of fuming nitric acid on phosphorus, a tremendous explosion ensued. The experiment was made by placing the fuming nitric acid in a

stout platinum crucible which rested on a stone slab, and dropping in the piece of ordinary phosphorus from the end of a rod which held it. The explosion followed immediately on the phosphorus coming in contact with the acid. A curious result of the explosion was, that while the sides of the platinum crucible were extended, the bottom was driven upward, so that the vertical cross-section was changed from the shape of a U to nearly that of a W.

In discussing the "Origin and Structure of Meteorites," *Pop. Sci. Month.* 29, 374–386; 1886, M. A. Daubrée says nothing in the exterior form of meteorites is more striking than a general aspect indicating that they are parts of a broken body. When we compare hundreds or thousands of stones of the same fall, we find that they all present polyhedral forms, like those of stones broken for a macadamized road, except that the angles are more or less rounded. Even meteoric iron exhibits this angular shape, showing that its malleability and extreme tenacity have not preserved it from a violent rupture. It seemed impossible that such effects could be produced solely by the action of the air, especially in the upper regions where it is in an extremely rarefied condition. But light has been thrown upon the problem since the introduction of the new explosives, which illustrate, in their industrial applications, the prodigious force that gases are capable of exerting, even in small quantity, when they are suddenly animated by a considerable tension. The explosion of a kilogram of dynamite will break up bars of steel which a pressure of a million kilograms would hardly crack. Similar conditions exist in the upper strata of the atmosphere, slight as their density may be, when a meteor moving with planetary velocity strikes upon them. The body compresses the air more rapidly than it can yield, and transmits an equivalent motion to its own molecules. Under these circumstances, in the successive detonations caused by an enforced rotation, iron and the most tenacious bodies will fly into pieces as if they were struck with a pile-driver.

There is another no less characteristic feature of the surface of meteorites which testifies to the violence of the mechanical action produced upon them by the atmospheric rebound, exhibited by rounded cavities resembling finger-marks. They appear in the stony meteors, but are particularly characteristic of the iron masses. These marks were at one time attributed to transient explosions taking place during the course of the meteor through the air; but experiment has shown that the same appearance is produced in

bodies which are acted upon by an explosion of dynamite, in the grains of coarse powder that drop, half consumed, from the mouth of a cannon when it is fired, and upon the touch-hole of the cannon. They are all due to the same cause—to the erosive action of gas revolving rapidly and moving spirally and under high pressure against the projectiles, boring into them as if it were a gimlet. The mechanical action is accompanied and aided by a chemical action which is dependent upon the combustible nature of iron at high temperatures. Although these blister-holes are worked only on the face which is exposed to the direct pressure of the gas, meteorites present them on various sides, and sometimes over their whole surface. This arises from the rotatory character of the motion of the body, which makes it present every side in succession to the front.—(*From Revue des Deux Mondes.*)

Dr. H. G. Piffard proposes the use of a mixture of gun-cotton and powdered magnesium for the production of a light by which instantaneous photographs may be made at night. The burning magnesium furnishes a light which is rich in actinic rays, and the burning gun-cotton supplies the heat necessary to cause the instantaneous combustion of the magnesium. The mixture has been flashed from a pistol.—*Newport News*, Oct. 31, 1887.

According to the *Sci. Am. Sup.* 25, 10230; April 7, 1888, a new use for soluble gun-cotton has been found in the manufacture of a fibre called "Artificial Silk." This fibre is prepared by De Chardonne by dissolving 3 grams nitro-cellulose in 100 to 150 cc. of a mixture of equal parts of alcohol and ether. 2.5 cc. of a filtered 10 per cent solution of ferrous chloride in alcohol, or of stannous chloride, and 1.5 cc. of a solution of tannic acid in alcohol are then added. The filtered liquid is placed in a vertical reservoir having at its bottom a blow-pipe nozzle of glass or platinum. This pipe forms an acute cone with an orifice of from 0.10 to 0.20 mm., the thickness of the margin not exceeding 0.1 mm., and opening into a vessel of water acidulated with one-half per cent. of monohydrated nitric acid. The level in the reservoir being some centimeters higher than in the vessel of water, the overflow proceeds easily. The fluid hardens at once in the acidulated water, and may be drawn out by a uniform movement in the form of a thread which must be dried rapidly by traversing a current of dry (not hot) air, and may be wound up as

soon as dry. Soluble coloring matters may be introduced into the solution so as to obtain threads of all colors.

The *Journal du Matelot* of Jan. 14, 1888, contains an account of an invention of M. W. Meissel's, of the North German Lloyd line, for throwing oil from a ship upon the billows which endanger her safety. This consists in attaching thin zinc cylinders, filled with oil, to the end of a rocket, so arranged that the explosion of the rocket shall rupture the cylinder and distribute the oil. Experiments were made from the Vesra in the middle Atlantic and they gave excellent results, and proved that they could be fired directly ahead either in the air or under water.

The *San Jose (Cal.) Mercury* of January 22, 1888, cites the results of several experiments with this rocket. In one experiment the rocket was thrown to a distance of 1000 feet. By the explosion of five rockets at from 1200 to 1500 feet from the ship, a space of from 1500 to 2000 square feet of water was covered with oil and the waves were at once smoothed. The rocket was fired 900 feet against a gale. The value of the invention to deep-water sailors consists in the certainty of explosion of the rocket at sufficient distance to leave the vessel in calm water during a gale.

The *Newport News* of April 2, 1888, states that a patent has been granted Mr. Timothy Akin, Sen., of Gosnold, one of our branch pilots, for a rocket or projectile made of metal and filled with oil, which is to be thrown from the shore near or around vessels that are stranded. It can be thrown from the same gun that throws the life line across stranded vessels. The rocket sinks in the ocean and the oil that is contained therein escapes and floats on the surface, which makes the water comparatively smooth and stops the sea from breaking, thus enabling the life-saving crews to work in smooth water while they are engaged in their perilous duty going to and fro from the stranded vessel saving life. Capt. Akin has tried them and they work well. He intends to send them to the different life-saving stations so that they can be fairly tested and tried.

Mr. Wolcott C. Foster gives in the *Engineering News* **19**, 254; March 31, 1888, a "List of Explosives Containing Nitro-glycerine," in which the names of some forty different explosives, together with the different grades of each and their nitro-glycerine contents, are enumerated.

PROFESSIONAL NOTES.

STEEL: ITS PROPERTIES; ITS USES IN STRUCTURES AND HEAVY GUNS.

By Wm. Metcalf, Trans. Am. Soc. Civil Engineers.

A Review.

The year just passed has been a notable one in the history of gun-making in the United States, not only because of the actual work accomplished and the promise of more to be accomplished in the immediate future, but almost equally because of the widespread interest aroused in the subject outside of military circles.

This interest has been evinced by the appearance of no fewer than six papers from prominent civil and mechanical engineers, four of which have been exhaustively discussed by officers of the army and navy and by many of the leading engineers, metallurgists, and inventors of the country.

The first impetus was given to the discussion by Mr. Dorsey's paper before the Naval Institute on Steel for Heavy Guns. This was followed in the Proceedings of the Institute by Mr. Wm. J. McAlpine's paper on the same subject, by Mr. W. F. Durfee's on Iron and Steel and the Mitis Process, and by Mr. A. H. Cowles on Aluminum Bronze. In March the subject was brought before the American Society of Civil Engineers by Mr. Wm. Metcalf. Finally, the last month of the year has brought a paper—just issued—on "Gun Making in the United States," from the pen of Captain Rogers Birnie, Jr., before the Military Service Institution at Governor's Island.

Every one of these papers should be read by all who wish to understand the metallurgy and manufacture of heavy guns. Taken together, they probably contain every argument which has been brought, or is likely soon to be brought, against the type of guns which has been adopted for the new armament of our ships and forts, together with the replies of ordnance officers and gun manufacturers to those arguments.

To us it seems that no impartial reader of these papers can fail to find in them abundant evidence of the wisdom shown in the selection of this type, or fail to be gratified at the way in which all arguments against it have been met and answered.

With the papers of Mr. Dorsey, Mr. McAlpine, Mr. Durfee, and Mr. Cowles, the members of the Institute are already familiar. It is proposed here to give them some information as to Mr. Metcalf's paper before the Society of Civil Engineers and the discussion which followed it.

The paper is in two parts, of which the first is devoted to a consideration of the nature, peculiarities, and treatment of steel, and the second to the use of steel for guns.

Toward the close of the discussion Mr. Metcalf expresses regret that the first part of his paper should have been overshadowed in the importance given to the second part by those who joined in the discussion; but this would seem to have been due not to any lack of interest in the views expressed upon the nature and treatment of steel, but to the almost universal consent with which those views were received.

However this may be, we of the Navy have much reason to congratulate ourselves upon the result, which is, that the discussion turned almost entirely upon that part of the paper relating to guns.

It is of course with this part of the paper that we shall principally deal, though nothing that Mr. Metcalf has to say of steel could fail to be of interest and value. His principal points, until he comes to gun-making, are summarized at the end of his paper and may well be given here in his own words.

"Iron and all metals are liquids.

"Cold steel is congealed iron, containing in solution various ingredients which give to it certain marked properties.

"Heat is the power which gives to steel all of its good and all of its bad conditions.

"Steel changes in volume and structure with every degree of heat that is applied to it, and the changes may be read in the fracture as surely as we read the changes in volume in the mercury column.

"Slow, quiet cooling from a high temperature causes the formation of large, irregular crystals and renders the steel weak.

"Quick cooling and agitation form small, uniform crystals and a strong condition.

"The application of heat alone will change the form and the size of the crystals.

"The change of volume due to a unit of heat increases as the content of carbon increases; therefore high carbon steel must be handled with exceeding care.

"The temperature to which it was last subjected, moderated by its subsequent treatment, is always recorded in the structure of steel, and may be read there if the piece be fractured.

"Annealing, making soft, ductile, and uniform in texture is the most important of all operations, from an engineer's point of view.

"Although annealing will relieve strains and change a coarse structure to a fine uniform grain, it must not be supposed for a moment that any amount of annealing will heal a rupture. I do not believe there is any cure for a rupture, because I do not believe steel can be welded.

"Steel being crystalline, has no fibre; therefore there should be no sharp angles, no sharp edges, and no unfilleted corners; the surfaces should be smooth and free from tool marks or indentations caused by sledge blows and the like.

"With our present knowledge, the best steel for structural purposes is that which is most nearly composed of iron and carbon.

"Finally, good steel, properly worked, is the most useful of all of man's productions, and it may always be relied upon to do its full work to its utmost limit; but if the laws of its being be violated it will as certainly respond, causing disappointment and disaster."

Great value is attached to annealing—the process, it will be remembered, upon which the advocates of our present system of gun-making have laid special stress, but the usefulness of which has been called in question by Mr. Dorsey and others. Upon this subject Mr. Metcalf's words should be conclusive. He says:

"It is a remarkable, and probably the most important property of steel, that no matter what the grain may be, no matter how coarse from overheating, or how irregular from uneven heating, if it be heated uniformly to the refining heat and kept at that heat long enough, the crystals will change in size and will all become small and uniform, so that the fracture will be so even that it will be called fine-grained and amorphous. . . . .

"If an ingot be annealed properly it will lose every vestige of its distinctive crystallization; it will become refined and tough."

Now as to guns.

Mr. Metcalf, it is well known, advocates a gun of steel cast on the principle

which Rodman applied with so much success to cast iron smoothbores. The built-up gun he condemns as unscientific and unmechanical, holding that the conditions sought in building up can never be practically attained by that system, but that they may be attained by the Rodman process of casting hollow and cooling from the inside. In his paper he proposes to apply this principle as it was applied by Rodman, casting the gun with a hollow core through which water circulates, at the same time keeping up the temperature of the outside by the application of heat in the pit. The object of this process is to place the successive layers of metal from the bore outward in a state of varying tension; that is to say, to set up internal strains. The gun is then to be annealed. But the object and effect of annealing, as Mr. Metcalf very clearly explains, are to *remove* all internal strains and to place the metal throughout the mass in a state of rest; that is to say, having gone to great trouble and expense to produce internal strains, he goes to still further trouble and expense to remove them. This inconsistency having been pointed out by Lieutenant Ingersoll and Lieutenant-Commander Barber, Mr. Metcalf shifts his ground somewhat and says that he thinks it would be more convenient to cast the gun solid, bore it out, and then proceed with the treatment. He says nothing, however, of any change in the order of treatment, and as his change of plan is based wholly upon convenience and not upon principle, it seems reasonable to understand that the order of treatment is to remain the same. In the Rodman process the tensions are set up in cooling the metal from a state of fusion. Annealing must of necessity follow this. If the gun is cast solid, bored out, and then subjected to the same treatment, it will be heated to a high temperature, cooled from the inside, and afterward annealed. This is still setting up internal strains by one process and removing them by another, so that the point made by Lieutenant Ingersoll and Lieutenant-Commander Barber is not met by this change of ground.

Later in the discussion the same point having been made by Mr. Marshall, Mr. Metcalf says, "Slow reheating to the right temperature will insure the formation of uniformly minute crystals and great strength, and, having secured these conditions, cooling from the interior, whether rapid or not, will secure initial tensions in the directions desired."

We are now surely far enough from the Rodman process of manufacture. The principle, it is true, is retained; the principle, that is, of varying tensions; but so is this principle maintained in the built-up gun. It is the very essence of the built-up system. The point at issue between Mr. Metcalf and the advocates of built-up guns is one, then, upon which neither side can justly appeal, as against the other, to the "spirit of Rodman." Both parties accept Rodman's principle, but both propose to modify his method, for the very excellent reason that they are dealing with a metal to which his method does not apply. There is no reason to assume that if Rodman were living to-day and engaged in the manufacture of steel guns, he would of necessity cling to the methods which he invented forty years ago for cast iron. He was, before all things, a progressive man, always in advance of his age, never lagging behind it. It may be remarked, however, that there seems a somewhat unjustifiable tendency in certain quarters just now to make a fetish of him. He was undoubtedly a remarkable man and a very able artillerist. He made guns which were perhaps the best of their day, but which were certainly not perfect guns. The opinion prevails very generally among the advocates of the cast steel gun that no Rodman guns ever failed. This is as far from the truth as the conviction held by the same people that a great many built-up steel guns have failed. The facts are all the other way. As noted by Lieutenant-Commander Barber, in the report of the Joint Committee on Ordnance, Senate, page 215, L. Congress, Third Session, there is a list of 249 cast-iron guns which have burst in the United States. Of these, 141 burst under fire, 10 burst spontaneously, and 98 cracked, fissured, or ruptured before proof. Of those which failed under fire, 24 were Rodman guns.

The Rodman process, then, did not make a reliable gun within its own proper limits of pressure, even of cast iron, the ideal metal for such a process; and the question naturally arises whether it can make a reliable gun for much heavier pressures, of steel, a metal many times more difficult than iron to cast. Assuming for the moment that the answer is in the affirmative; assuming that Mr. Metcalf can cast a gun solid, without blow-holes or other defects, bore it out, heat it uniformly throughout its huge and irregularly shaped mass to exactly the right temperature for annealing, maintain that even temperature for the proper time, and finally cool it from the inside, preserving such relations between the rate of cooling of the inside and outside of this irregular mass as shall insure the proper relations of tensions for the successive layers; assuming all this, will he in the end have a cheaper gun than can be made by manufacturing it in parts so small that each can easily be made perfect, treating each with reference to the strain it will have to stand in the finished gun, and then assembling these parts? Mr. Metcalf desires that his system should be considered chiefly with reference to very heavy guns, "from 100 to 150 tons." The casting (solid) for a gun to have a finished weight of 100 tons would weigh not far from 250 tons. This mass of metal having been cast with all the precautions necessary to secure uniformity, must be taken from the pit and put in the lathe to remove the sinking head and cut the bore. It must then be returned to the pit and there subjected to the treatment which is to give it its uniform granulation and its characteristic tensions, after which it must be again transferred from the pit to the lathe to be finished.

The mere handling of such a mass of metal must be a heavy item of expense, but a far heavier one will result from the proportion of failures which will be found an inevitable feature of the process.

Mr. Metcalf objects to the consideration of the castings that shall be lost in the pit "unless the makers of built-up guns will report every defective ingot as a failure of a gun." But the failure of an ingot for a built-up gun is not the failure of a gun. It is a failure and means the loss of only a small part of a gun, while the failure of a cast gun in the pit means the loss of the whole.

It must be agreed that cast iron is a far easier metal to deal with than cast steel, yet in a recent attempt at South Boston to cast the body of a 12-inch rifle (of cast iron), three failures were made before a successful result was produced. The weight of the finished piece required in this case was only 35 tons.

As to the expense of such disastrous failures, Mr. Wm. Sellers—a practical steel manufacturer of large experience—has said that if he were required to cast guns in one piece he would require a higher price than for a built-up gun, because of the proportion of castings which must be rejected. Mr. Metcalf himself sets the probable cost of the gun he proposes at from 20 to 30 cents per pound. But figures more precise than these have become available since Mr. Metcalf's paper was written. Bids have been received for the casting of a steel 6-inch gun in a single piece, the gun to be rough bored and turned only. The firms who bid on this did not propose to treat the gun by any such elaborate method as that of Rodman, still less by the modified method suggested by Mr. Metcalf. They proposed simply to cast the gun much as they would cast anything else, and then to bore it out and anneal it. Thus they were relieved from a very important part of the expense inseparable from Mr. Metcalf's method, and from all the expense of finishing, rifling, making and fitting the breech mechanism, etc.

Two bids were received for this very simple casting of 11,000 lbs. weight. They were: Pittsburg Steel Casting Company, $3300, or 30 cts. per pound; Standard Steel Casting Company, $5300, or 48 cts. per pound. The mean price then at which the manufacturers of this country are willing to furnish the rough castings for a gun in one piece is 39 cents per pound. If we add 10 cents for finishing, we have 49 cents per pound as the price of the gun.

Mr. Metcalf quotes figures from "Holley's Ordnance and Armor" to show that built-up guns cost from 70 to 80 cents per pound. Holley's figures are

just 23 years old, and are, as nearly as may be, just double the corresponding prices of to-day. The price of Whitworth steel built-up guns was quoted six years ago at 38 cents per pound. They are probably somewhat cheaper now. French steel guns cost about the same.

The Gun Foundry Board, whose careful and conscientious work has received universal commendation, estimated the cost of building guns in this country at between 37 and 38 cents per pound.

This estimate may be too low, and the estimate of 48 cents for the cast gun may be too high, but it seems certain, at least, that no such extreme difference of price exists in favor of the cast gun as would be inferred from Mr. Metcalf's figures.

The discussion of the paper was opened by Lieutenant Danenhower, who spoke very briefly. He said, "I should like to ask Mr. Metcalf what becomes of the compression of the Rodman gun after the gun is annealed." To this Mr. Metcalf replied, "What becomes of the hammering after the gun is annealed?" But the object of hammering and that of annealing are not opposed to each other. They both aim to produce uniformity and fineness of granulation, whereas the object of annealing and that of the Rodman process of cooling are directly opposed.

Mr. Metcalf continues: "In making a gun, if the first preparation by annealing does not give that condition of strength and fineness necessary, it is perfectly obvious to any one that a simple way to get it is to heat it to the proper point and bring every part of the steel to the best condition, then cool from the interior of the gun."

Commander H. B. Robeson, U. S. N., inquired as to the relative weights of built-up and of cast guns.

Mr. R. W. Hunt, M. A. Society C. E., while stating that he had had no experience in making guns, expressed a "strong hope that the theory of the steel cast gun will prove to be right."

Captain O. E. Michaelis endorsed the views of the lecturer and condemned the built-up gun.

Colonel W. C. Church said, "I am sufficiently well acquainted with Mr. Metcalf's views to be quite sure that I endorse what he has said."

Lieutenant W. H. Jaques, U. S. N., differed radically from the lecturer. As is well known, Mr. Jaques is a firm believer in the built-up gun. He calls attention to the magnificent endorsement of the building-up system involved in the willingness of a great commercial firm like the Bethlehem Iron Company to erect a plant for the manufacture of steel built-up guns, expressed long in advance of any guarantee that a single contract would be awarded them; and contrasts this with the position of the advocates of the steel cast gun, who, having the plant already on hand, await a positive order from the Government before committing themselves to the investment of the sum needed for the manufacture of the first gun on their system.

Dr. R. J. Gatling expressed the opinion that "steel for gun construction should be neither too hard nor too soft." He is a believer in cast guns.

Mr. F. Collingwood, M. A. Society C. E., thinks the cast gun is deserving of a trial, and that its rejection without trial can only be set down to the account of prejudice.

Mr. J. M. Knap, M. A. Society C. E., coincides with Mr. Metcalf in his view that the best heavy gun of the future will be that known as the steel cast gun. As regards smaller guns of 8-inch caliber or less, he says: "Such satisfactory results have been obtained both in Europe and in this country with built-up guns made of forged steel, that our Government should be encouraged in their efforts in this direction." He continues: "The essayist has given us the bright side of the Rodman cast iron gun. It has its dark side as well. I well remember, while associated with Mr. Metcalf in the manufacture of guns at Fort Pitt Foundry, our losing two or three 15-inch Rodman guns by their breaking in the mould."

Mr. A. H. Emery gives an unqualified endorsement of the built-up gun. Of the cast gun he says: "I think in regard to the low cost of the solid cast gun (I mean by that a steel gun cast in one piece and cooled from the interior), that we shall not find the cost low, but the quality may be. I do not expect to live until we can make a large mass of steel as good as the small masses have been made. As regards the cost I agree with Mr. Sellers, who says in regard to making guns in one piece, that if he were to do it he would require a greater price than for built-up guns. He would consider the difficulty of getting a gun of good quality so great, so many of them would be condemned, with the balance all uncertain, that he would greatly prefer to forge the gun in pieces and bore out and assemble them. As to what the gun of the future will be I may say briefly this—built-up gun of steel; and I would say that my experience as an engineer teaches me that the smaller the mass we finish the pieces of steel in, working it by the hammer or hydraulic forging, the better we shall find its quality: the smaller the mass the better we can inspect and know whether it is good."

Mr. John Coffin, A. M. Soc. C. E., contributes a long and very important paper upon steel, from which we have space to extract only his conclusion, which is to the effect that the steel cast gun has little prospect of success. He says: "The difficulties are great. A very large piece of varying section, uncertainty of maintaining desired temperatures throughout, a limited knowledge of the effect of these temperatures, and the great cost of all experimental work in this direction, lead me to believe that the day is very far distant for Pittsburgh's dream to be realized.

"I am a patriotic believer in American talent and enterprise, and if solid steel gun construction is ever successfully accomplished, I would like to have the honors here, but in our struggle to again gain the front let us not, like the crawfish, go backward."

Commander C. F. Goodrich, U. S. N., writes very briefly, expressing his confidence in the built-up gun, but adding, "The naval service is not, I trust, bigoted, and if Mr. Metcalf or any other person can give it weapons as efficient, as light, and as safe as those now coming into use, with the added merit of greater cheapness, I am sure they will be welcomed."

Lieutenant-Commander Barber quotes numerous authorities to show that while steel cast guns have long been advocated, no success has thus far been attained in their attempted manufacture. He refers especially to the experience of Terre Noire, "the most famous steel casting establishment in the world," where success has been attained in the casting of small gun hoops, but where, in spite of the large amounts of money expended and the practical encouragement given by the French Government, no further advance has been made, even to the larger parts of built-up guns. Several of Mr. Barber's other points have already been noted.

Lieutenant R. R. Ingersoll, after pointing out the inconsistency already referred to, of setting up initial strains by the Rodman method only to remove them by annealing, gives some figures as to the strength of a cast gun without initial tensions, and asks how the elastic strength of the cast guns would be computed. "The strength of guns should be a matter of computation just as surely and accurately as in the case of any other mechanical structure."

Mr. W. Sellers says: "In this discussion I propose to confine my remarks to the question of guns, for the reason that I find no other point in Mr. Metcalf's very able paper upon which to hinge a discussion; and even as to this, I am not prepared to say that the American gun of the future will not be a solid mass of cast steel, but only that I doubt it; because, although this may prove to be the cheapest way to make great guns in the future, it does not appear to be so now, and with the improvements in progress it is less likely to be so hereafter.

"If we could assume that every great casting for a gun would prove perfect, one very important element of cost would be eliminated; but if the present

high standard is to be maintained, it may be safely affirmed that a notable quantity of such castings will be condemned, and then what shall we do with them? We cannot permit such vast masses of material to cumber the ground, and it will cost far more than the material is worth to cut it into pieces small enough to remelt; and yet this is all that we can do, and the cost of doing it must be added to the cost of the good castings.

"The casting of an ingot heavy enough to make the tube of a sixteen-inch gun, boring it and forging it to the proper length, would be accompanied with far less risk than to cast the same weight in one piece of that length, with a core throughout cooled on the Rodman principle; and I believe that the cost need not be greater, while the quality of the material would be far more uniform in the forged piece, not solely because it was forged, but because the quality of the short ingot would be more uniform than that of the long casting. That the built-up gun is unmechanical, or that the quality of the material in such guns cannot be had in as perfect condition as in the solid casting, I do not believe."

Mr. Chas. A. Marshall, M. Am. Soc. C. E., contributes a long and very interesting paper, from which we can extract only a few salient points. He says: "Disadvantages of casting the gun as a whole on the Rodman system are:

"First.—Enormously greater weight and size of casting: largely increasing risk of making. Cast iron is easier to handle than steel, yet the South Boston Foundry lost three castings before they succeeded with one.

"Second.—Very much slower cooling, which is the condition favoring un-uniformity by segration. The Rodman process doubtless seems to some minds a quick process of cooling, which is so, considering the size of the castings. Yet General Rodman states (Senate Rep. Com. 266, XL Congress, 3d Session, p. 80) that the time of cooling a 15-inch hollow cast gun was about six days, and that the outside temperature did not fall below 500 or 600 degrees temperature for about two days.

"Third.—As another consequence of the slow cooling, large, weak crystals.

"Fourth.—As another consequence of the slow cooling, a very low elastic limit to the outer metal certainly, and for the inner metal a higher value, but for the same kind of steel not anything to approach the treated gun tube quoted by Mr. Metcalf from Holley. The elastic limit to the outer metal would not be over 29,000 pounds per square inch for metal having same carbon contents as gun-hoop steel, which, it may be borne in mind, is the hardest steel used in the guns to-day—such metal as Cambria Iron Works are producing in hoops with an elastic limit of 55,000 pounds minimum by specification. . . .

"It may be profitable to enumerate in the most general way some of the advantages which the system of building up guns has over that of casting them whole: They are:

"With metal of equal strength, greater ductility. With metal of equal ductility, greater strength. Metal of more reliability, because (1) the blow-holes, if any, have been closed up or got rid of; (2) thorough tests can be made.

"Character of metal is known throughout. Character and amount of strains are known throughout and are controllable, so that two guns of same pattern are stressed the same. . . .

"The Rodman gun was an intelligent attempt to make a high power gun out of weak material; we have much superior guns to-day, though very few of them. If the hollow cast (or solid cast) steel gun has a field, it is as a low power gun for commerce-destroying or hasty inland defenses. In times of peace the policy of this nation being defensive, we do not want to invest money in commerce destroyers which would be useless in defending our ports, nor do we want to arm an expensive swift cruiser, even though unarmored, with inferior guns, albeit the cruiser would have to run away from an armored vessel. For coast defenses no guns but the best, because if ever used it will be against the best that the enemy has or can get."

Mr. Henry M. Howe thinks the difficulties to be met in making a steel cast

gun are less than those which Rodman met and overcame in applying his principle to cast iron. He says: "In view of the advantages of economy and of rapidity of production, I believe that the chances of producing by the Rodman plan a steel gun equal if not, indeed, superior to the best built-up gun, are sufficiently great to warrant the outlay required to settle the question by actual large scale tests."

Mr. Alfred E. Hunt, M. Am. Soc. C. E., in the course of an interesting paper which is largely devoted to other matters than gun manufacture, says, "I agree with Mr. Metcalf most cordially in his advocacy of the Rodman principle for the manufacture of steel guns."

Professor W. H. Burr, M. Am. Soc. C. E., says: "The experience of engineers with ordinary steel castings does not seem to me to justify confident expectations regarding the reliability of a gun produced by casting from steel with internal cooling. I am of course aware that the metal put into guns would not be precisely the same as that used for ordinary castings, but it is a very serious question in my mind whether such a mass of steel with no forging either in the liquid or solid state (for cooling is not forging) would be even approximately homogeneous.

"I do not assert it would not be, but in the absence of such a gratifying result as a large homogeneous steel casting free from gas fissures or bubbles, I do not believe that positive predictions on that side of the question can be at once accepted.

"In reasoning from cast iron guns to cast steel, it also seems to me that difficulties are not altogether avoided. In the first place, it is not an exaggeration to say that a gun of given caliber, in order to meet the requirements of modern ordnance, must do double the duty of the same gun under similar circumstances twenty-five years ago. Hence any fault in the material due to any part of the process of fabrication will result in far greater relative and absolute damage to the gun. If, therefore, the process of casting and cooling should prove to be more delicate and difficult to control with steel than with iron, as would probably be the case, the resulting product would be of most doubtful value.

"It seems to one not an expert in ordnance material that the first evidence of the fact that the requisite steel, with proper degree of homogeneity, high elastic limit and toughness, can be fabricated without forging either in the liquid or solid or semi-solid state, is yet to be produced.

"Hammer forging may be damaging to the material, but hydraulic forging is not, nor is forging in the liquid state, such as is obtained by the Whitworth process. It certainly is a fact that the best and most highly effective modern ordnance has been manufactured under processes involving those operations, with subsequent hardening and annealing. If the process of building up guns places the right kind of metal in such position and condition as to best resist the high intensities caused by firing, it certainly cannot be called unscientific. But if better results can be obtained at less cost by casting and internal cooling, by all means let us have them. Thus far, however, we have them on paper only, and that step is not a long one."

Mr. L. L. Buck, M. Am. Soc. C. E., says: "The practicability of making a steel cast gun successfully must depend upon whether a steel cast gun of such massiveness as is required for a large gun can be produced sound and strong enough to give it the required strength per square inch of section. If so, there appears to be no insurmountable obstacle to produce a successful gun in the manner proposed by Mr. Metcalf, as, without doubt, the other requisite conditions could be acquired as well with the steel castings as with iron castings. The unit strength of the metal could be considerably less in the cast than in the forged gun and yet make a stronger gun."

Mr. Gustave Lindenthal, M. Am. Soc. C. E., suggests that possibly the Mitis process would afford a solution of the difficulties involved in gun manufacture. "Supposing a tube of fine hard steel (to resist the abrasion from the shot or

projectile) as a core, around which were cast by the Mitis process the body of the gun of wrought iron; it would melt the outside of the hard steel tube, become thoroughly welded to it and form one whole piece. The ferro-aluminium used in the Mitis process as an addition to wrought iron is claimed to also prevent the crystallization of the cooling metal, which in addition has greater strength than wrought iron alone. It seems to me in that direction there is yet a field for great developments."

Mr. Theodore Cooper, M. Am. Soc. C. E., says: "I believe a steel cast gun can be made which can compete successfully with any form of built-up guns; but I fully realize that there is a costly experimental stage before success is reached. Having faith in our ability to improve upon the best European practice, I would like to see our manufacturers given a fair chance. They should not be expected to enter upon the expense and study without a proper reward in expectation." A. M. K.

A METHOD OF FINDING THE ELASTIC STRENGTH OF A METAL WITH THE RIEHLÉ HYDRAULIC TESTING MACHINE.

By Ensign J. H. GLENNON, U. S. N.

The method used with the Rodman testing machine, of finding the elastic strength of a metal, being impracticable with the Riehlé machine, owing to the slip of the liquid in the hydraulic cylinder past the piston, the following method, which requires no linear measurements, may be employed. Use is made of the fact that within the elastic limit a metal specimen stretches proportionally to the pull upon its ends. The method is best illustrated by a case in which it was successfully tried.

A steel specimen of the ordinary length, diameter .5 inch (area of cross-section .2 square inch), was placed in the machine. A load of 3000 pounds, equivalent to a tension of 15,000 pounds per square inch, was then applied by means of the crank, which was then stopped in order that the ordinary measurements of the specimen might be made. As might have been expected in a Riehlé machine, the weight scale settled down. After measuring the specimen the crank was turned until the scale again lifted at 3000 pounds, when the machine was stopped and a chalk mark placed on the top of the belt-wheel, the scale weight at the same time being moved to 4000 pounds. The crank was then turned as uniformly as possible until the scale lifted, the number of turns and fractions of a turn being counted. The crank was then stopped and measurements made, during which the scale settled down as before. The old chalk mark was erased, and after measuring the specimen the crank was turned uniformly until the scale again lifted at 4000 pounds, when it was stopped, a chalk mark placed as before, and the scale weight moved to 5000 pounds. The crank was then turned till the scale lifted again. The number of turns and fractions of a turn were counted as before, the rate of turning being as uniform as possible and, as nearly as could be judged, the same as before. This process could of course have been carried on until the specimen broke.

In the case cited, the number of turns of the crank between tensions of 15,000 pounds and 20,000 pounds per square inch (on scale, between 3000 pounds and 4000 pounds) was 5; between 20,000 pounds and 25,000 pounds, a little more than 4; between 25,000 and 30,000 pounds, 4; the number of turns for each additional 5000 pounds gradually became uniform at 3, until a tension of 60,000 pounds per square inch was reached. Between tensions of 60,000 pounds and 65,000 pounds per square inch, the number of turns of the crank was 10, thus plainly showing that the elastic limit had been reached. The elastic strength of the metal was therefore placed at 60,000 pounds. The specimen broke at 108,000 pounds.

The excess of 5 turns, at the beginning of the test, over 3, just inside the elastic limit, was probably due to the fact that the machine grips had not at the beginning gotten a firm hold on the specimen. Previous to the test above mentioned, absolute uniformity in the number of turns at the higher tensions had not been expected, and probably could not be in a poorer machine. In any case, however, some law, according to which the number of these turns increase or decrease, can always be found; and the instant this law is broken the specimen is at its elastic limit.

Uniformity in turning the crank is desirable, in order to prevent shocks in the hydraulic cylinder which might lift the scale. Absolute uniformity, however, is not required, care in turning being all that is necessary.

The time occupied in chalking the wheel and in moving the weight along the scale should be as small as possible consistent with uniformity of interval.

The above method can also be employed in finding the elastic strength for compression. A wrought iron specimen 1 inch in length was subjected to compression. Below a compression per square inch of 55,000 pounds, the number of turns necessary to increase the compression 5000 pounds was between ¾ and ½. Between 55,000 pounds and 60,000 pounds, the number of turns of the crank was between 1½ and 2, thus plainly showing the elastic limit as before.

LIQUID FUEL FOR TORPEDO-BOAT BOILERS.

Translated from the *Rivista Marittima* by Lieut. J. B. Briggs, U. S. N.

Note.—The article in the *Rivista* is a translation of an article in the *Génie Civil* of Paris, by Jules D'Allest, chief engineer of the Fraissinet Company of Marseilles.

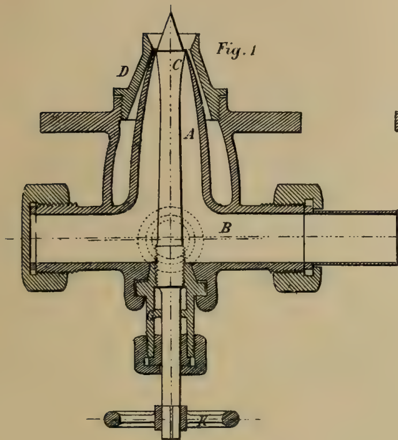
We have published an essay on the heating of boilers by means of naphtha and its residuum, in which we describe our apparatus built for such boilers and the experiments made with the same.

The Ministry of Marine, after having tried (in competition with other similar apparatus) our sprayer on the boilers of the torpedo boat La Chevrette, has recently requested us to study up the subject of a sprayer especially for torpedo boats. In response to this invitation, we have entered again into the consideration of the subject, though from a new standpoint, on account of the element of forced draught, which is an important point in considering ships in which it is necessary at whatever cost to reduce to a minimum the weight of evaporating apparatus in order to gain speed.

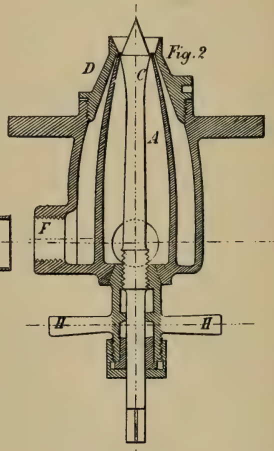
Description of the Sprayer.—The sprayer that we have designed for boilers of ordinary draught, and which was experimented upon at Cherbourg, consists of a conical chamber of bronze to which the liquid is conducted through a tube. The mouth of this chamber is closed by the plug *C*, which, managed conveniently by the valve-wheel, can open or close the mouth of the chamber, leaving between its outer conical surface and the inner corresponding surface of the chamber an annular opening varying in width from 0 to 2 mm. Through this annular opening the petroleum penetrates into the furnace in a stream of the shape of a hollow cylinder. The steam, led to the sprayer through a pipe, surrounds the chamber, heating the contents, and, escaping in a stream of cylindrical form through the space before mentioned, surrounds the petroleum, reduces it to spray, and projects it with force into the furnace. This combustible, thus reduced to the finest spray, ignites on contact with any burning body and burns without flame. The force of the fire is regulated by the valve, which can be moved forwards or backwards, thus diminishing or increasing the quantity of hydrocarbon introduced into the furnace.

By employing two similar sprayers placed side by side, the control of the fire is rendered very easy. It can be instantaneously extinguished or lighted simply by closing or opening the cock that regulates the admission of petroleum

Sprayer with Natural Draught.

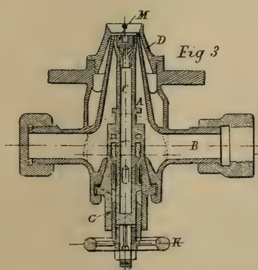


Longitudinal Section.

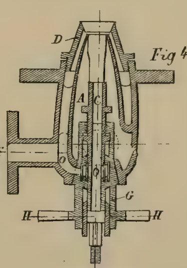


Transverse Section.

Sprayer with Forced Draught.



Longitudinal Section.



Transverse Section.

in each sprayer. If the apparatus becomes obstructed with solid substances contained in the naphtha, or fouls from lengthy work, it will be sufficient to turn slowly to the right and left the hand-wheel, and thereby regulate the flow of the liquid. If it should be desired to take a look at the interior of the chamber, give a half turn to the hand-lock-wheel and then withdraw the sleeve and the valve.

These sprayers work well and can burn from 10 to 80 kilos of petroleum per hour. A couple of similar sprayers capable of burning 160 kilos of naphtha can then evaporate (in the proportion of 13 liters per kilo of combustible) 2080 liters of water per hour; and supposing that there were an evaporation of 30 liters of water per square meter of heating surface (such being nearly the normal results obtained with ordinary draught), this would correspond to a furnace having a heating surface of 69 square meters. Now, at sea it rarely happens that a furnace has greater heating surface than 50 square meters; it can then be admitted that the apparatus above described, applied to a furnace, can largely fulfill all requirements.

Considering, however, a torpedo-boat boiler, it is necessary to evaporate per square meter of heating surface a quantity of water rather larger than 30 liters, which is possible, of course, having recourse to forced draught. Instead of 160 kilos of petroleum, it might be necessary to burn in one furnace double that quantity, or possibly even more.

To accomplish this, it seems at first sight that it would be necessary to increase the diameters of the apparatus above described; but such is not the case. In fact, with this increase in size, although the petroleum will flow more abundantly into the furnace, still the pulverization will be imperfect, and the result will be incomplete combustion and a dense black smoke, which will foul the boiler and retard evaporation.

To avoid these difficulties, more pulverizing power is necessary. To obtain this, we have added inside the jet of naphtha a second jet of steam. The naphtha thus comes out enclosed by two pulverizing streams, and it all passes in complete spray.

The apparatus that satisfies these conditions is composed, like the first, of a conical box into which the petroleum flows from the tube *B*. The pulverizing agent (steam or air) comes through a tube, and, passing into the cone, forms the external jet that surrounds the petroleum. It also passes at the same time through an orifice into the stem of the regulating valve, from whose mouth it is forced by the cone's mouth into the furnace in the form of a conical stream inside the naphtha. This apparatus is regulated like the first. It can burn up to 400 kilos of naphtha per hour without producing smoke.

It is now necessary to determine the least dimensions to be given to the various parts of a boiler destined to burn a given quantity of combustible, and it is therefore necessary to determine experimentally the greatest evaporation that can be obtained per unit of heating surface both with natural and with forced draught.

Experiments in Evaporation.—These experiments have been made with a return-tube boiler of the type of auxiliary boilers used on the decks of merchant vessels for running windlasses, winches, etc.

The dimensions of the aforesaid boilers are:—

Normal pressure, 3.50 kilos.

Covered heating surface	direct, meters	3.30
	tubular, "	16.70
	Total	20.00
Calorimeter of tubes, square meters		0.1555
Evaporating surface, "		2.57
Calorimeter of smoke-stack, square meter		0.1520
Volume of steam, liters		1130
" water, "		2500

Some necessary changes were made in the furnace. The grate was taken out and was replaced by refractory fire brick, with a bridge-wall to assure the intimate mixture of the gases.

The door and the furnace front are in the case of ordinary draught replaced by a plate, with a door in the lower part, to which are attached the sprayers. The petroleum is fed from a tank placed by the side of the boiler.

With forced draught the furnace is hermetically closed by a cast-iron front, on which are fixed the sprayers, and this has a pipe through which the air is driven by a steam blower into the interior of the furnace. The petroleum is fed to the sprayer by a donkey pump. Two manometers indicate constantly the air pressure.

With natural draught combustion is complete ; the petroleum burns without smoke. The fire can be regulated by the sprayers. We have in this way succeeded in evaporating the greatest possible quantity of water, and have reached a limit beyond which we cannot pass either by increasing the number of sprayers or the amount of petroleum.

The following table is a résumé of the experiments :

With Natural Draught.

	Number in Order of Experiments.									
	1	2	3	4	5	6	7	8	9	10
Duration in hours of experiment	4.15	4.10	3.58	3.06	5.20	6.28	4.00	4.36	2.07	5.20
Kind of combustible—Astatki.										
Consumption of combustible in kilos :										
Total—kilos	260.29	210.53	242.37	183.74	283.26	382.78	245.00	267.95	107.18	336 85
Per hour, kilos	61.24	50.52	61.10	59.27	53.11	59.19	61.25	58.25	50.63	63 16
Per sq. meter of grate surface and per hour	69.57	57.40	69.41	67.34	60.34	67.24	69.59	66.18	57.52	71.76
Temperature of feed-water	23°	24°	28°	28°	27°	28°	28°	27°	27°	28°
Pressure in boiler—kilos	3	..	..	..	..	..	..	..	..	..
Water evaporated :										
Total—kilos	3100	2700	2900	2100	3400	4425	2800	3100	1300	3900
Per hour, kilos	729	648	731	677	637	684	700	673	614	731
Per sq. meter heating surface	37.38	33.23	37.48	34.71	32.66	35.07	35.89	34.51	31.48	37.48
Per kilo of combustible	11.90	12.82	11.96	11.42	11.99	11.55	11.42	11.55	12.12	11.57
Same reduced to 100°	13.81	14.85	13.77	13.15	13.83	13 30	13.15	13.32	13.98	13.32

Average quantity of water evaporated per kilo of combustible, 11.83. Same taken at 100° and evaporated at atmospheric pressure, per kilo of combustible, 13.65.

The result of this is that the evaporation reached 37 kilos per sq. meter of heating surface, but that it was not possible to pass this limit. If it were attempted to increase the activity of the fire by increasing the amount of petroleum, smoke would be produced and the evaporation remain stationary.

The greatest evaporation as above obtained is therefore remarkably above that which can be obtained with coal. In fact, with natural draught and using coal of the best quality, the evaporation has never, in the same boilers referred to, passed beyond 28 or 30 kilos for the same unit of heating surface.

The above limit of 37 kilos being reached, it is not possible to increase the rapidity of the circulation of the heated gases in the uptake without recourse to artificial draught, with which it is only possible to obtain a more active evaporation.

Finally, the combustion of petroleum, employing forced draught, is effected without difficulty. The apparatus regulated, and the relations determined between the consumption of petroleum and the quantity of air for combustion furnished by the blower, it is not necessary to attend further to the fire. The

boiler can work indefinitely, the only thing being for the fireman to watch the supply of water and petroleum.

The following table is a résumé of the results obtained in the experiments with forced draught:

Table of Greatest Evaporations with Forced Draught.

	Number of Experiment. 1	2	3
Duration of experiment, hours	1.30	4.30	6.00
Kind of combustible—Astatki.			
Consumption of combustible:			
Total, kilos	213.92	608.44	784.68
Per hour, kilos	142.61	135.21	130.78
Per sq. meter of grate surface and per hour, taking for example a grate surface in the proportion of $\frac{1}{32}$ the heating surface, as in the torpedo boats of 525 horse-power	375	350	344.16
Per sq. meter of grate surface and per hour, taking for example a grate surface like that of the Marceau	331.65	314.44	304.16
Temperature of feed-water	16°	18°	17°
of the smoke-box	350	302	380
of air-chamber	25	20	28
Pressure on boiler, kilos	3	...	...
Water evaporated:			
Total, kilos	2200	7119	9432
Per hour, kilos	1464	1582	1572
Per sq. meter heating surface, kilos	73.20	79.10	78.60
Per kilo of combustible	10.27	11.70	12.02
Per kilo, reduced to 100°	12.01	13.68	14.06
Pressure of blast:			
In supply-pipe, mm	45	42	45
In tube-box, mm	10	8	8

This last table shows that by the use of petroleum with forced draught the evaporation reaches extremely high limits, a great deal higher than those that can possibly be obtained with coal; and note that by increasing the supply of petroleum and air into the furnace we should have been able to obtain still greater evaporation. That was not possible, it is true, during these experiments, very violent foaming taking place, which, as it was impossible to ascertain the water level in the boiler, obliged us to moderate the activity of the fire; but it would be possible in a boiler capable of withstanding greater pressure than 3 kilos, which we could not go beyond in the boilers employed. As is well known, the greater the pressure, the more foaming is retarded.

Comparison with Coal.—With the boilers of the torpedo boats of 525 horse-power, they succeed at the most in burning 800 kilos of coal per hour, evaporating from 6.5 to 7 liters of water per kilo of coal. Taking the highest figure, the total evaporation is then 5600 liters per hour. These boilers having 100 sq. meters of heating surface, the evaporation per sq. meter is therefore only 56 liters, while the average taken from the table is 76.96 liters. Besides the experiments made with torpedo boats, others more complete were made on shore by the Ministry of Marine with a boiler of the Marceau. In these, in fact, they were able to push the evaporation to the maximum. The boiler had been placed in a room hermetically sealed and connected with the blower.

The following table contains the most important results of the experiments:

Résumé of Experiments of Evaporation with Forced Draught made with Boiler of the Marceau.

	Dates.				
Duration, hours	5	5	4.35	5.3	5.15
Kind of combustible—Mattonelle d'Anzin.*					
Consumption of combustible:					
Total kilos	6610	8235	9013	9980	10,830
Per hour, kilos	1322	1647	1966.52	1976.4	1977.3
Per sq. meter of grate surface and per hour	200.66	250	298.5	300	297.1
Temperature:					
Feed-water	19°	23°	..	11.5°	11°
Smoke-box	440°	491°	481°	524°	514°
In air-chamber	28.5°	34°	..	26°	23°
Pressure in boiler, kilos	6.05	6.05	5.91	6.02	6.1
Water evaporated:					
Total, kilos	55,193	68,185	70,121	78,748.50	83,357.80
Per hour, kilos	11,038.70	13,637	15,298	15,593.80	15,887.70
Per sq. meter of heating surface and per hour.	36.4	44.977	50.457	51.53	52.53
Per kilo of combustible	8.35	8.28	7.78	7.89	8.03
Per kilo of combustible reduced to 100°	9.85	9.77	..	9.468	9.636
Pressure of blast:					
In supply-pipe, mm	20.1	28	66.4	68.5	64.7
In tube-box	1.5	5.8	..	8.7	8.6
Air consumed per kilo of coal burned, mc.	9.73	10.5	11.3	10.27	9.64

* Some kind of prepared fuel in brick shape.

As is seen from this table, the greatest evaporation obtained was 52.30 liters per sq. meter of heating surface.

In the Navy it is often preferable to take as terms of comparison the quantity of coal burned per sq. meter of grate surface rather than the quantity of water evaporated per sq. meter of heating surface.

It is easy to apply this method to a comparison of our petroleum boiler with the coal-burning boiler of the Marceau, taking account of the relative calorific powers of the two combustibles and supposing a grate surface proportioned to the heating surface. With petroleum we have succeeded, in the boilers above described, in evaporating 1582 liters of water per hour. Now, the coal employed with the Marceau's boiler having evaporated a maximum of eight liters of water, if we had employed this combustible instead of petroleum, we should have burned, to evaporate the same quantity of water, $\frac{1582}{8} = 197.70$ kilos of coal.

On the other hand, in the boiler of the Marceau the proportion of grate surface to heating surface being 1 to 46, the hypothetical grate for our experimental boiler will have a surface of $\frac{20}{46} = 0.43$ sq. meters. We should then have burned per sq. meter of grate and per hour $\frac{197.70}{0.43} = 457$ kilos of combustible, or 52 per cent more than that burned in the boiler of the Marceau, which was only 300 kilos.

The comparison with the torpedo boats of 525 horse-power, in which, during the experiments, the fires were pushed to the utmost, brought us to the same results. The boilers of these boats, in fact, evaporate at the most 7 liters of water per kilo of coal, and the proportion between heating and grate surfaces is $\frac{1}{52}$. Besides, there are burned 800 kilos of coal per hour, or $\frac{800}{1.90} = 420$ kilos per sq. meter of grate and per hour, the grate surface being 1.95 sq. meters. Now, if we institute with these boilers the same comparison as that made for the Mar-

ceau, we shall have that our experimental boiler would have burned $\frac{1582}{7} = 226$ kilos of coal on a hypothetical grate of $\frac{20}{52} =$ sq. meter 0.38 surface, or $\frac{226}{0.38} = 594.73$ kilos of coal per sq. meter, and therefore 43 per cent more than that of the torpedo boat.

In connection with the experiments on the Marceau and the torpedo boats above cited, we must for the sake of impartiality cite those that were made some years since in England on the boilers of the Thornycroft torpedo boats, under direction of the English Admiralty, and which were published in *Engineering*.

From the following table (which comprises the results of the final experiments, indicating an evaporation of 84.9 liters per sq. meter of heating surface, with a combustion of 466 kilos of coal per sq. meter of grate) it resulted that the English boilers are more powerful than the French with forced draught, which, it is true, reached 150 mm. of water:

Experiments on Boilers of Thornycroft Torpedo Boats.

	Order of Experiments.			
	A	B	C	D
Duration of experiments, hours	2.00	2.07	1.30	1.77
Quantity (*sic*) of combustible—Cardiff-Nixon.				
Pressure of air in millimeters of water:				
In air-chamber	50	75	100	150
In ash-pit	36.7	57.2	80.5	131.2
In smoke-stack	33.7	46.7	75	108.2
Number of revolutions of fan	575	665	818	986
Temperature, Centigrade:				
On deck	8°	14°	9.5°	14.45°
Air-chamber	23.9	29.5	25.5	27.7
Smoke-stack	578	644	682	784
Of feed-water	12°	14°	12°	13.3°
Pressure of steam, kilos	8.2	8.2	8.07	8.07
Quantity of coal consumed:				
Per hour, kilos	416	529	662	816
Per hour and per sq. meter of grate,* kilos	237	302	378	466
Water evaporated:				
Per hour, liters	2940	3496	3196	4878
Per hour and per sq. meter of heating surface,† liters	51.2	60.0	73.1	84.9
Per kilo of coal	7.06	6.60	6.33	5.97

* Grate surface, 1.75 sq. meters.
† Heating surface, 57.40 sq. meters.

We shall be very careful not to throw doubt on the abilities of the engineers who directed the experiments tabulated above, but it must however be admitted that the results obtained by them cannot be accepted without great allowance, especially in regard to those marked D, whose duration was too short to inspire much confidence. The engineers who had to conduct trials of steam engines in England know that the short duration of a trial greatly diminishes its value, and that in general the results obtained under normal conditions are somewhat inferior to those obtained on the trial. On the other hand, no one can doubt the knowledge and experience of the engineers of the French marine; therefore, in spite of the English experiments, we persist in believing that what the French have obtained with French boilers represents truly the maximum that can be obtained.

We do not believe that, excepting those made by us and before explained, there have been any other experiments on the combustion of petroleum with forced draught; at any rate, our experiments, though incomplete, show (leaving out of consideration the English trials) that with the same draught, the boiler burning petroleum has an evaporating power much superior to one burning coal; and here we propose to show, calculating the volume of air necessary to combustion, not only the volume of the products of combustion in the two cases, but that such superiority is fully supported by theory.

Volume of Air Necessary to Combustion.—Carbonic acid being formed of 27.36 parts of carbon and 72.64 of oxygen, it will require to burn a kilo of coal, obtaining all the carbonic acid, $\frac{72.64}{27.36} = 2.65$ kilos of oxygen, or $\frac{2.65}{1.43} =$ mc. 1.85 of oxygen, 1.1026 being the density of the oxygen, and 1.30 kilos the weight of a cubic meter of air. Now, air being composed of 21 per cent oxygen and 79 per cent nitrogen, there will be required to burn a kilo of coal $\frac{1.85 \times 100}{21}$ = mc. 8.88 of air. Burning hydrogen will form water, which contains 11 per cent hydrogen and 88.9 oxygen. There will therefore be required to burn a kilo of hydrogen $\frac{88.9}{11.1} = 8$ kilos oxygen, or 5.594 mc. of oxygen, or 26.638 mc. of atmospheric air.

Crude naphtha, or its residuum, which we are considering as a combustible, containing about 87.1 per cent of carbon, 11.7 per cent of hydrogen, and 1.2 per cent of oxygen, the volume of air necessary to the combustion of a kilo of this combustible will therefore be $0.871 \times 8.88 + \left(0.117 - \frac{0.012}{8}\right) 26{,}638 =$ mc. 10,800. Now, Péclet has found experimentally that when a combustible is burned on a grate, the best results are obtained when there is introduced into the furnace a volume of air 33 per cent greater than that theoretically sufficient. It is true that in the combustion of naphtha, the mixture of the combustible with the air being very intimate, it is probable that the theoretical amount will be sufficient. However, in order to have plenty of air we shall accept the surplus.

The quantity of air to introduce into the furnace to burn a kilo of *astatki* will therefore be $10.8 \times 1.33 =$ mc. 14.36.

But, to burn a kilo of coal, 8 cubic meters of air are necessary; there will be, then, applying the indicated per cent of increase, $8 \times 1.39 =$ mc. 10.64.

This volume, as a result of the table in regard to the Marceau experiments, is sensibly equal to that obtained in practice.

Volume of the Products of Combustion.—With equal temperature and pressure, the volume of carbonic acid evolved in the combustion of coal is equal to the volume of the oxygen that formed it.

A kilo of hydrogen requiring for combustion 8 kilos of oxygen, it results that each kilo of oxygen consumed will give 1.125 kilos of water-vapor, or $1.24 \times 1.125 = 1.4$ mc. (about) of vapor reduced to zero.

At atmospheric pressure, and 0°, a kilo of oxygen occupies a volume of mc. 0.70, while each kilo of oxygen converted into vapor increases in volume by mc. 1.4 — mc. 0.7 = mc. 0.7. In other terms, burning hydrogen, the volume of vapor produced is double the volume of oxygen employed. Burning a kilo of *astatki*, the products of combustion will then be $0.87 \times$ mc. 1.85 = mc. 1.609 carbonic acid, $0.117 \times 2 \times$ mc. 5.6 = mc. 1.310 of steam; and when mc. 14.36 of air are used (of which mc. 1.609 of oxygen has been used to burn the carbon, and $\left(0.117 - \frac{0.012}{8}\right) \times$ mc. 5.6 = mc. 0.646 to burn the hydrogen), there will remain an excess of 14.36—1.609—0.646 = mc. 12.105 of nitrogen and oxygen not combined.

The total volume of the products of combustion of a kilo of *astatki* will then be $12.105 + 1.609 + 1.310 =$ mc. 15.024.

This volume is calculated at 0° ; we must therefore refer it to the temperature of the furnace and to that of the smoke-stack if it is to serve as the basis of calculation of the respective sections. This correction is not, nevertheless, necessary, being useful instead to serve to establish the following comparison between petroleum and coal boilers.

Comparison between the Power of Evaporation of Coal-burning and Petroleum-burning Boilers.—In a boiler burning coal, to consume a kilo of combustible there must pass into the uptake mc. 10.64 of products of combustion to evaporate the maximum of 8 liters of water. In a boiler burning petroleum, however, to burn the same quantity of combustible it is necessary to consume mc. 14.36 of the same products ; therefore 13 liters of water are evaporated. In other words, to evaporate a liter of water it is necessary with coal to circulate in the boiler $\frac{10.64}{8} =$ mc. 1.330 of air, and with petroleum $\frac{14.36}{13} =$ mc. 1.104. Or, for the circulation of one cubic meter of gas in the flue, the boiler evaporates, employing coal, $\frac{1}{1.330} = 0.75$ liter water, and employing naphtha, $\frac{1}{1.104} = 0.90$ liter. The result of this is that, with equal sections of tubes, and consequently equal heating surface, and with same conditions of draught, with naphtha the same boiler evaporates $0.0 - 0.75 = 0.15$, whence $\frac{0.15}{0.75} = 20$ per cent more than with coal.

It therefore also follows that to evaporate the same quantity of water in a unit of time with the same draught, the petroleum boiler can be 20 per cent smaller than the coal-burning boiler. Now we have found in practice a still greater difference, caused by the fact that in burning coal there is introduced into the furnace a much greater quantity of air than is theoretically necessary ; while with petroleum, on the contrary, this quantity of air is reduced on account of the intimate union of the combustible and the supporter of combustion (air in this case), and on account of the uniform flow of the two, all which brings the combustion nearer the theoretical conditions. This observation, and the comparison previously made between the products of combustion in the two cases, explain the considerable evaporation that we have demonstrated in our experimental boiler.

[NOTE.—A section on the inconveniences attending the use of the present type of torpedo-boat boiler is omitted here.—TRANSLATOR.]

Boilers burning Petroleum under Forced Draught.—In view of the difficulties attending the use of coal with forced draught, and of the dangers of the usual type of torpedo-boat boilers, the question naturally arises, why not agree to experiment on a vast scale and seriously in regard to the employment of petroleum on board those vessels, using a boiler specially adapted to that combustible ?

This idea was, it is true, first brought out by the *Compagnie des Forges et Chantiers*, of Havre, which had also taken out a patent. Unfortunately, however, this company (although improving and modifying) had appropriated the idea of a petroleum grate of Sainte Claire Deville, who was satisfied with making the petroleum flow into the furnace through little pipes slightly inclined. Now this could not be a satisfactory solution of the problem. Indeed, in the apparatus of the company of Havre, the air employed had a pressure of 8 or 9 centimeters only, which, as we shall better see presently, is wholly insufficient to effect the pulverization of the combustible, so that the combustion was effected by simple contact. Naturally the result obtained was very mediocre ; the production of steam was very feeble ; the apparatus was very likely to foul ; so that after a few experiments the system was abandoned without receiving any further application. The experiments that we have described in the beginning of this study show that, using the pulverizers, the problem is solvable with certainty of good results.

The boilers in actual use could be replaced by others with closed furnace, whose general form might be the same, and whose dimensions might correspond to the figures that ought to be adopted in the torpedo boats of 525 horse-power. In these boilers, as soon as the grate is done away with, the furnace, instead of being square, would have the same form as the fire-box, so that the shell of the boiler would be cylindrical throughout its length.

There is no doubt that a similar boiler, fed with petroleum, would be wholly free from the danger of blisters, which form in plates of coal-burning boilers. The presence of an opening in the hearth would make it elastic, thus eliminating the danger from grooving and cracking (of plates). Moreover, this elasticity, permitting the tube-box to expand and contract independently of the shell, would certainly diminish the danger of steam escaping from the tube-sheet. This, however, would still be directly exposed to the flames.

But it is to be noted that doing away with the grate permits the construction of a return flue in the petroleum boiler. Now, a boiler constructed on this plan would probably work very well, even with extreme forced draught; a fire-box of the kind adopted in the boilers of the Marceau would allow expansion, and the tubes would be secure against the flame impacts that they receive when placed in the prolongation of the back connection. In both these boilers the front part of the furnace is made of a cast plate, which, that it may not get red hot, has water circulating inside. The pulverizers are fixed on this plate, and receive the petroleum from a reservoir placed at the boiler's side; and the pulverizing agent (steam or compressed air) comes to the pulverizers by means of a tube.

The air, forced by the blower, arrives at the pulverizers by means of a fitted pipe, and divides in two currents that penetrate to the furnace through the orifices. These two currents meet the jet of burning naphtha at right angles, a disposition that secures the intimate commingling of the two, and which, as we may be able to prove experimentally, gives results much better than those obtained by sending the blast in the same direction as the petroleum.

This disposition has also another advantage: the blast of air coming at a right angle loses some of its velocity, which in the furnace becomes $\frac{q}{\Omega}$ (Ω being the section of the furnace) instead of $\frac{q}{\omega}$ (ω being the section of the supply-tube), which it was at the mouth of the tube. This diminution of velocity allows the heated gases to remain longer in the furnace and the tube-box, and therefore to give up more completely the heat they contain. A door allows the entrance of air into the furnace when it is desired to resort to natural draught, and two other smaller doors allow the introduction of balls of burning cotton to start fires.

The boiler with direct tubes has the same dimensions and the same weight as the boilers in use on the 525 horse-power torpedo boats.

The return-flue (or flame) boiler is a little heavier than the other; but it must be noted that naphtha having much greater power than coal, the dimensions might (for same steam power) be notably reduced.

The boilers considered above answer the following conditions:

	Direct tube boiler.	Return-flue (or flame) boiler.
Normal pressure, kilos	9	9
Total covered heating surface, sq. meters	99.50	98.80
Tubular section inside of tube ferrules, sq. meters	0.22	0.22
Diameter of tubes	40×44	46×50
Distance between tube-sheets	2.850	3.45
Number of tubes	238	166
Total evaporating surface, sq. meters	6.23	6.45
Same per horse-power, sq. meters	0.0119	0.0123

	Direct tube boiler.	Return-flue (or flame) boiler.
Proportion with heating surface	$\frac{1}{16}$	$\frac{1}{15}$
Volume of steam, mc.	2.640	2.720
Volume of steam per horse-power, liters	5	5
Volume per sq. meter heating surface	26.4	27.15
Weight of steam consumed per hour for 525 horse-power (at 10 kilos the horse-power), kilos	5,250	
Weight of petroleum to produce this steam per hour, kilos	437	
Volume of air necessary per hour, in the ratio of 23 cubic meters per kilo of petroleum	8740	
Same necessary per second	2.427	
Section of air-supply tube, sq. meters	0.1213	
Velocity of air per second in supply-tube, meters	20	
Pressure of blast in col. of water, $h = \frac{V2}{2g} - \frac{\delta^1}{\delta}$	0.026	

Arrangement of Boilers and Petroleum Reservoir.—The arrangement is most simple. The fire-room can remain in free communication with the outside air. The blower sends into the furnace the necessary air for combustion by means of pipes. The remainder of the arrangements are not changed. The petroleum tanks are tin, and are situated on each side of the boiler, where the coal-bunkers usually are. A reserve deposit may be made by covering over with thin plating the frames of the ship. A special donkey-pump conveys the oil from the deposits to the reservoirs for distribution to the pulverizers.

Substitution of Compressed Air for Steam in Pulverizing the Petroleum.—On board a torpedo boat, the water supply being limited, it would be highly inconvenient to employ steam as a pulverizing agent, as the amount required would equal one twentieth of the amount the boiler could produce.

But this inconvenience can be obviated by employing air instead, with which the pulverizing is effected equally as well as with steam; and, besides, a whiter flame is produced, especially when using heated air, while the result is sensibly the same as with steam. Employing cold air, the apparatus sometimes gets extinguished suddenly, which does not happen with heated air, especially if the furnace is fitted with refractory brick, which get red hot rapidly, thus assuring perfect regularity in the fire.

The temperature to which it is necessary to heat the air is not very great; 50° or 60° will be enough. It would be well to lead the air through the steam-space or the smoke-stack. Employing air on lighting the fires, a greater pressure must not be used than 0.400 to 0.600 kilo. The fires well under way and the furnace hot, the pressure can be increased to one kilo; but the best average pressure is 0.75. It is to be noted, however, that with compressed air the flame produces continuous roaring, rather intense, similar to the noise of a large blower. This phenomenon, which is not noticed when steam is employed, is probably due to a succession of lighting and extinguishing which follow at very brief intervals, and must have the same origin as those produced by the "chemical harmonic" tubes; it is therefore probable that it would be done away with if, instead of using atmospheric air, we were to employ the products of combustion. This can be easily done, and as these products escape from the smoke-stack at a high temperature, the necessity of heating will be done away with; it would even be necessary to cool them so as to avoid damaging the pump. This cooling, however, must not be carried too far, since the gaseous products contain watery vapor from the combustion of the hydrogen which might tend to impede pulverization. Some months ago, in England, there was much said in regard to the employment of compressed air as a pulverizing agent, putting the idea forward as a new and great discovery. The talk was all for nothing, since every time that steam has been employed in

pulverizing a liquid, the question has been considered as to the employment of air or some compressed gas to obtain the same results. We, ourselves, some years ago conducted trials in pulverizing with compressed air. The *Forges et Chantiers* at Marseilles, up to 1883, experimented with a pulverizer imported by the Russian Admiral Likatchoff, in which they substituted compressed air for vapor. This application in fact offers nothing new.

Volume of Air necessary to Pulverization, and Volume of the Compressing Pump.—To pulverize one kilo of naphtha we must have about 500 liters of air at a pressure of .75 kilo.

As the boilers of the 525 horse-power torpedo boats should burn at the most, at full speed, 300 kilos of naphtha per hour, a pump capable of furnishing 300 cubic meters an hour, or five cubic meters a minute, will give a volume of air more than sufficient to assure the pulverizing. A direct-acting Westinghouse pump of 300 mm. diameter, with a stroke of 300 mm., running at 60 revolutions, will be sufficient for the work.

Air-Tank for Use in starting Fires.—For starting fires it will be necessary to have a reservoir containing compressed air which will arrive at the furnace at a pressure of 0.75 kilo by means of a pressure-regulator. The capacity of this reservoir can be easily determined, knowing the quantity of naphtha to pulverize in order to obtain in the boiler steam at a tension sufficient to work the pump.

The boiler contains 2850 liters of water, which it will be necessary to heat to 130°, corresponding to the pressure at which the pump can begin work; but it must be observed that until the pressure in the boiler is obtained, the air comes in at ordinary draught, and consequently the quantity of combustible burned is much less than when the fires are well under way. It thence results that the volume of heated gases, being smaller, pass only through the upper tubes, so that the lower part of the boiler is still cold while the upper part is already under pressure. Therefore we can count on being obliged to heat only 2000 liters, instead of 2850, without danger of falling below limits.

To increase the temperature of the 2000 liters to 130°, supposing the air of the boiler at 10°, it will be necessary to consume 2000 (130 — 10) = 240,000 heat units. The volume of steam contained in the boiler being 2640 liters, it will be necessary, in order to refill it with steam at 130°, to evaporate mc. 2640 × 1.50 = 3960 kilos, or 4 liters of water taken at 130°, and convert them into steam at the same temperature. The consumption of heat by this evaporation will be

$$\lambda = (606.5 + 0.305\ \mathrm{T} - \mathrm{T})\ 4$$
$$= (606.5 + 0.305 \times 130 - 130)\ 4 = 2064.60.$$

The total number of heat units to be consumed to put the boiler under pressure will therefore be 240,000 + 2064.60 = 242,064.60. Naphtha producing about 11,000 heat units per kilo, it will be necessary to consume $\frac{242064.60}{11000} = 22$ kilos naphtha, and therefore to use 22 × mc. 0.500 = 11 cubic meters of air at a pressure of 0.75 kilo.

If we take a 120-kilo reservoir, like those on board the torpedo boats for charging torpedoes, the capacity of the reservoir will therefore have to be $\frac{11 \times 0.75}{120} =$ mc. 0.068.

Résumé of the Advantages in employing Naphtha on Torpedo Boats.—From what has been said, it is seen how easily the boilers of torpedo boats can be heated with petroleum, and it is easy to evaluate the considerable advantages that arise from this system.

As we have before observed, by removing the air-chamber from in front of the boiler, not only shall we do away with the depressing moral effect to which the firemen are now subjected, but we shall also avoid an actual danger liable to occur at any moment. The management of the boiler will be most simple,

resolving into a mere watching, instead of requiring as at present a numerous personnel who must be experienced men and who are difficult to obtain.

From a military point of view, it is to be remarked that with a non-smoke-producing fuel like petroleum, a torpedo boat would not be seen from afar, as happens at present—in the daytime, on account of the streams of smoke; at night, on account of the burning material escaping from the smoke-stack. Naphtha having a calorific power greater than that of petroleum, its employment would permit, with the same weight of combustible taken on board, a longer stay at sea. In fact, coal, evaporating in the torpedo boats 7 liters of water, and naphtha 12 liters, the distances run, with equal amounts of the two combustibles, would be in the proportion of $\frac{12}{7}$; that is to say, if the torpedo boat using coal runs x miles, the one using petroleum would run $x \times \frac{12}{7}$ miles.

We have also already said that with equal heating surfaces the petroleum boiler can evaporate 20 per cent more than the coal-burning boiler; therefore we could build a petroleum boiler which would be 20 per cent lighter than a coal-burning boiler of same power.

The boilers of this last system for torpedo boats of 525 horse-power, weighing 8000 kilograms about, would probably decrease the weight of the torpedo boat by about 1600 kilograms, which would allow, still having the same power of boiler, a sensible increase of speed.

Besides the wholly peculiar interest that heating by petroleum presents in the question of torpedo boats (in which it is necessary to sacrifice everything to speed, even at the cost of having a useless weapon), it is also to be remarked that the substitution of naphtha for coal solves in a simple and practical way the problem of forced draught, to which constructors are constrained to pay attention in answer to the always increasing demands in regard to the speed of steamers.

The employment of this combustible would also permit notable reductions in the dimensions of the immense boilers that must be employed when it is desired to obtain great speed. If to this is added the economy of personnel and space that results from using this combustible, it is seen that this is an excellent reform which must not be lost sight of, and which will perhaps be generally adopted in the near future.

However, first of all, it is necessary to resolve the difficulty of a supply of naphtha. The question is not insolvable, and we even believe that we are on the eve of a definite solution. It creates, in fact, such an interest as to form daily subject for discussion and studies so important that probably we shall have occasion at another time to take the question up for examination.

GUN-MAKING IN THE UNITED STATES.*

By Captain ROGERS BIRNIE, JR., Ordnance Department, U.S. Army.

[Reviewed by Lieutenant A. GLEAVES, U. S. N.]

In this permanently valuable book the author "aims to give a history of gun-making and gun trials in the United States, with special reference to the part taken therein by the War Department in the past fifteen years." The first half of the book is devoted to the consideration of the cast iron period, which continued until about 1872, and then in natural order are discussed the succeeding ten years of experimentation. The last two chapters on steel cast and forged built-up steel guns are of special interest at this time of burning questions as to what shall be the ultimate accepted type of gun. They contain a clear and concise mathematical discussion of the theory of the construction of steel cast guns, and descriptions of experiments conducted by the Ordnance

* Monograph VIII., Military Service Institution of the United States.

Department for the purpose of investigating the principles of mechanical engineering involved in the construction of built-up steel guns. There is also an admirable diagram, drawn to scale, graphically illustrating the changes "in radial dimensions" which took place in assembling the 8-inch gun. "The degree of accuracy obtained (in shrinking) was 98 per cent of the mathematical result anticipated."

In a book which deserves only praise it may seem captious to find fault, but the curve of powder pressure which is plotted on the plan of the 8-inch B. L. steel rifle shows a muzzle pressure of only 2.9 tons, while the elastic resistance curve at the same point is 955, hence the factor of safety at the muzzle is 3.3, which is out of all proportion to that at the breech, where it is only 1.5. If therefore these curves are correct, it is not clear why the gun should be hooped to the muzzle as Captain Birnie states is now done. The latter half of the book especially merits the careful study of every one interested in guns and gun-making.

Appendix C, on the "alleged failure of steel guns," enumerates fourteen well known and often quoted accidents to certain guns, with counter statements which show that in not a single case has there been a failure of the modern type of built-up steel guns.

Whatever Captain Birnie writes on the subject of guns demands attention, and his arguments in favor of the built-up system carry with them the weight of recognized authority.

During the war, and for a few years afterwards, the superiority of our shell guns was unquestioned, but when the question of penetration and power of guns arose, and cast iron was proved by actual trial to be an unsuitable metal for guns, we commenced to fall behind the rest of the world and have never regained our place, although in a fair way to do so now.

Our ordnance history in the seventies is somewhat brighter. It is marked by the conversion of the old and "comparatively worthless" smoothbores of large caliber into rifled muzzle and breech loaders, and whether it was a mistake or not to attempt the development of *both* systems, a gun was evolved of indisputable worth. Notwithstanding the 8-inch M. L. R. converted from the 10-inch S. B. (Army) was an acknowledged "makeshift," and is not to be compared with the modern type, its energy is sufficient to penetrate the armor of "a large proportion" of the war ships of the world, and upon it we must depend for some time to come.

About 1872 the revival of the gun question by the discussions and investigations of the various Boards and Ordnance Committees appointed to consider the subject, brought forth many private inventions of more or less merit, some of which excited much interest and comment in the press throughout the country. It is sufficient to mention two, the multicharge gun and the wire-wound system. Interesting accounts are given of the trials of both. The former finally failed at Sandy Hook in 1883–84. The wire-wound gun (10-inch) burst after the 93d round, but the system impressed the Board as possessing sufficient merit to warrant the recommendation of further experiments.

In 1871 "the trials of cast iron rifles, pure and simple, were practically abandoned," but twelve years afterwards, in accordance with the act of 1883, the War Department was obliged to design a 12-inch B. L. R. of cast iron. It was a strange recommendation of the Logan Committee, in the face of experience with this metal abroad, where it had been discarded by all the gun-making powers after exhaustive trials. One is reminded of the backward step taken in England when, after a trial of five or six years, breech loaders were superseded by muzzle loaders, to which the English artillerists clung with stubborn persistency for fifteen years, when they were compelled to return to breech loading.

In the matter of ordnance the Navy has been more fortunate than the Army, and it is pleasant to read the generous credit Capt. Birnie accords to the Navy for its success in steel-gun building. Since the inauguration of steel, in

1883, the Naval Bureau of Ordnance has not been hampered with the construction of any guns other than steel. The Army, on the other hand, has not yet been permitted to shake off its fetters of cast-iron. The cast-iron 12-inch B. L. R. (model of 1883) has been completed and proved at Sandy Hook. "Taking the average result—charge 265 pounds, projectile 800 pounds, pressure 28,000 pounds, and M. V. 1750 f. s.—we find the power of this gun is represented by a M. E. of 1700 foot tons nearly." This performance Captain Birnie says, "entitles it to be classed as a safe medium power gun of the caliber," but also states that "the bore was so badly scored by erosion that at the 96th round the Board did not consider it safe to continue the firing."

"Including the rifle mortars there are three different types of combined cast iron and steel guns in hand at the present time, viz. a 12-inch B. L. R., mainly of cast iron, but lined with a steel tube inserted from the rear and forming about one half the length of the bore; a 12-inch B. L. R. with cast iron body, strongly reinforced by a double row of steel hooping extending from the breech to a distance forward of the trunnions—the trunnions themselves forming part of one of the hoops—and a steel tube lining as in the first gun; and two 12-inch rifled mortars alike in general construction, but one a muzzle loader and the other a breech loader." There are also two 10-inch B. L. wire-wound guns partly constructed, one with a tube of cast iron, the other with a tube and longitudinal bars of forged steel. "The 10-inch wire-wrapped cast iron rifle will have 28 calibers length of bore and weigh 29 tons." The 10-inch steel gun will weigh 22 tons and have a bore 30 calibers long. The peculiar feature of this gun will be the longitudinal bars which are intended to give it longitudinal strength. They will encircle the gun like a cylinder and extend from the breech to about one half the length of the gun.

The 12-inch mortars are short rifled pieces; they weigh about 9 tons, have a charge of 52 lbs. and throw a 610-lb. shell a distance of very nearly five miles.

Forged built-up steel guns were authorized by Act of Congress in 1883, and one year ago an appropriation of $20,000 was made for the manufacture of three steel-cast 6-inch guns; one to be of Bessemer, one of open hearth, and another of crucible steel. The last was not bid for; the first has been cast at Pittsburg, and is said to be nearly ready for shipment to Washington, where it will be finished and then sent to the proving ground at Annapolis for proof and statutory tests.

"The trial of one 6-inch steel cast gun of a given make may prove something in regard to 6-inch guns, but in the face of past experience and present widespread distrust of the suitability of unforged (or unpressed) steel guns, can do little to predicate what result will be obtained with larger calibers."

"Another great necessity for making the small calibers at present appears to lie in the capacity of steel works for making such castings, for there is no doubt but that a special plant must be yet provided for making the larger calibers of steel cast guns. This is one of the items of expense which, combined with others, will probably make the cost of production of a gun of large caliber quite as expensive if made in this way as if made of forgings and built up.

"The amount of metal used for the hollow castings made or attempted for 12-inch cast iron rifles was about 240,000 pounds, or somewhat more than double the weight of the finished piece. The rule of double the weight holds good in heavy steel castings. Taking for example a 12-inch steel gun, the heaviest casting required for a built-up forged steel gun of this caliber is 40 tons, to be cast in the simplest form of a solid ingot. This gives a rough finished forging of 14.5 tons weight, also less than half that of the casting. Applying these rules to the massive casting of a 12-inch steel cast gun, the weight of casting if made hollow would exceed 100 tons, and if made solid would exceed 120 tons at the least estimate allowable. And for this massive casting a special plant, flask, and all the adjuncts must be provided. If we go to 16 inches caliber, the comparison is 84 tons as the heaviest casting for the forged steel

gun against not less than 250 tons for the steel cast gun. Considering the extreme difficulty of making sound steel castings of even a few tons weight at the present time, how long may it be before such castings as these can be manipulated? For guns of such caliber, then, it may be said the steel cast system is, from present lights and practices, a question of the future.

"The feasibility of making castings for steel cast guns up to 10-inch caliber (weight of casting about 60 tons) seems within reach of appliances that might be readily provided, but that such guns, or even smaller ones, can be made of good sound material possessing the requisite physical qualities to compare in strength, endurance and power with built-up forged steel guns of the same caliber, cannot be conceded. To even approach this it would be indispensable that the steel cast gun should be made with the proper degree of initial tension. The Rodman method of casting has been proposed, but whether intended to accomplish the introduction of initial tension or not has not been made quite clear by its advocates. The slow process of cooling incident to this method would cause the formation of large weak crystals in the casting, and, apparently recognizing this, the advocates of the method have proposed to remove all the initial tension strains by an after annealing. This would, moreover, appear to be a wise precaution, inasmuch as this method of casting is so uncertain in cast iron and would be much more so in steel, with its greater shrinkage and liability to crack from internal strains in casting. If, then, the Rodman method is not used for the purpose of introducing initial tension, the hollow casting is certainly a bad form, as proved by Whitworth's trials and tribulations with it. The unsoundness found in the centre of a solid cast ingot is in this case only transferred to the middle of the walls of the gun—a result in every way bad and which no subsequent treatment can correct."

It should be a matter of congratulation in this country that the highest type of the modern gun is the embodiment of American ideas. The breech closure, the benefit of the principle of initial tension, the shrinkage of layers of cylinders over each other, were all the original conceptions of our own people, although each system was developed abroad.

The first built-up forged steel gun constructed in the United States was begun in 1879 at South Boston for the Navy Department. It was completed in 1882 and proved at the Naval Experimental Battery. It was an experimental gun of medium power and its mark was not duplicated. It did its work well and was the beginning of what may be called the steel age of our naval ordnance.

"Since the commencement of the active work allowed by appropriations in 1883 and subsequent years, the Navy Bureau of Ordnance has procured the forgings for, and completed or nearly so, twenty-one 6-inch, eight 8-inch and two 10-inch rifles. Work on a third 10-inch rifle, to be 34 calibers in length of bore, has been commenced, with forgings now at the Washington Navy Yard.

"Of these guns the West Point Foundry contracted for the manufacture of five 6-inch and two 8-inch rifles. Four of the 6-inch are completed and the remaining guns are in the final stage of construction. The South Boston Iron Company contracted for the manufacture of six 6-inch and two 8-inch rifles. Five of the 6-inch are completed, and the two 8-inch are to be completed in March, 1888.

"The Washington Navy Yard has completed two 5-inch, ten 6-inch, four 8-inch and one 10-inch rifles, and has another 10-inch about three-fourths completed. Carriages for all these guns have also been made there, besides a number of 3-inch guns and projectile work.

"At present the Washington Navy Yard has worked up its plant to a capacity for a yearly produce of twenty-five 6-inch and ten 8-inch guns and carriages. Plans are now in process of development which will make the yearly capacity of the Yard equal to completing twenty-five 6-inch, four 8-inch, six 10-inch and four 12-inch rifles, or a proportionate number of any given calibers.

"In their main features the Navy and Army steel guns are alike, the most

important difference in construction being that, in the Navy guns, the trunnion hoops are made of oil-tempered and annealed castings and are screwed on cold, while in the Army gun designs these hoops are forged and assembled by shrinkage. In the matter of charges also the practice differs, in that the rule in the Navy is to use a charge of powder equal to about one half the weight of the shot, while in the Army the weight of projectile is made proportionately much heavier. The lighter projectile gives a high velocity with a relatively flat trajectory, which is best adapted, as it is claimed, to the conditions of naval combat."

The excellence of the new Naval guns is shown in the following table compiled from the official firing sheets:

	Weight in pounds.	Length of bore in calibers.	Weight of powder charge.	Weight of projectile.	I. V. F. S.	Pressure in tons.	Date of Firing.
5-inch steel B. L. R....	6200	24.6	32	60	2046	15	Aug. 1887.
6-inch " " ...	11,000	24.4	54	100	2105	15.6	Mar. 1886.
8-inch " " ...	28,000	24.6	112	250	2024	15.2	Nov. 1887.

BIBLIOGRAPHIC NOTES.

AMERICAN CHEMICAL JOURNAL.

VOLUME 10, No. 2, MARCH, 1888.

J. P. Cooke, assisted by T. W. Richards, with the view of testing Prout's hypothesis, has redetermined the atomic weight of oxygen by the combustion of weighed amounts of hydrogen. The mean of sixteen determinations gives $O = 15.953 \pm 0.0017$ ($H = 1$). H. N. Morse and W. M. Burton find that the hydrogen formed by the dissociation of water at the temperature of the oxidizing flame will diffuse through platinum. This would account for various cases of reduction in platinum vessels hitherto unexplained. F. G. Novy has prepared some of the higher homologues of cocaine. C. R. S.

ANNALEN DER HYDROGRAPHIE, ETC.

PART I, 1888. The surface currents in the southwestern part of the Baltic, and the influence of the wind. Remarks on Fitzroy river and its navigation to Cooktown, east coast of Australia. Observations on the west coast of Africa between Burguela and Mossamedes, from report of commander of German gunboat Habicht. Extracts from cruise reports of Captain Nichelson from Port Natal to Port Adelaide. Barasona, Pinta Palmas, Petit Tron, on the south coast of Hayti. Contributions to the description of the coast of Kaiser Wilhelms Land. Daily and annual variations of force and direction of the wind on the island of Lisma, explaining the character of the Bora and the Scirocco. A few magnetic observations in the North Sea. Instrument for determining the position of the ship near shore (description of the Rittenhouse chart table and position finder). Meteorological and hydrographic notes.

PART II, 1888. Variations in the height of water in the Caspian, Baltic, and Black seas, with reference to the weather. Observations of temperature, specific gravity, transparency and depth of water and character of bottom in the Baltic and North seas. Notes on the navigation on the west coast of Africa. The calculation of the deviation of the compass, with investigation concerning the first observations of Capt. Flinders. Quarterly review of weather observations by the Termen Meteorological Bureau. Meteorological and hydrographic notes. J. T. S.

ENGINEER.

JANUARY 27, 1888. Riggs high speed revolving steam engine; illustrated.

FEBRUARY 3. Forced draught; letter.

FEBRUARY 10. On the construction of furnaces for burning liquid fuel; illustrated. Forced draught; editorial.

FEBRUARY 17. Bennett's geometric compasses; illustrated.

With this instrument, ellipses of any size or shape, polygons and other geometrical figures can be drawn as readily as circles with ordinary compasses.

On the combustion of coal, and some evaporative experiments with natural and forced draught.

FEBRUARY 24. On the construction of furnaces for burning liquid fuel. Nordenfelt submarine torpedo boat. Quadruple expansion engines of the S. S. Suez; illustrated.

MARCH 2. Do marine boilers supply wet steam?—editorial.

MARCH 9. On the construction of furnaces for burning liquid fuel; illustrated.

MARCH 16. The Nordenfelt submarine boat; illustrated.

MARCH 23. The development of the marine engine in the British Navy.

"Since 1885, with a few minor exceptions, all new engines of the navy have been on the triple-expansion principle, and with boiler steam pressures of at first 130 lbs. per square inch, gradually increasing to 155 lbs. in 1887. A further gain in economy has thus been effected which is variously estimated. From 15 to 20 per cent over the compound engine of the same pressure is often given as the amount of gain, and probably 15 per cent may safely be taken as not too much."

On the construction of furnaces for burning liquid fuel; illustrated.

MARCH 30. On the relation between power and speed in steam vessels. The Eclipse Corliss engine; illustrated. A new torpedo boat.

W. F. W.

ENGINEERING.

JANUARY 6, 1888. Naval manœuvres; editorial.

JANUARY 13. Rapid firing arms.

JANUARY 20. The Howell torpedo; editorial. The torpedo boat Fatum.

This boat, built by Orlando & Bro., of Leghorn, has given remarkable results as regards manœuvring power, steaming and steering astern.

Torpedo boat casualties.

A new departure in brazing and welding; letter.

The cheapening of the production of oxygen by Brin's process has put into the hands of metal workers a new power. Brazing can be done quickly with a mixture of compressed oxygen and coal gas, and iron welds made that were not possible with the coal gas alone.

JANUARY 27. Propeller planing machine; illustrated. Electrical welding; illustrated.

A method devised by von Bernados, of St. Petersburg, different from any previous system and seems thoroughly practical. Promises to be especially valuable for repair work in shops and perhaps on shipboard.

Miscellanea.

Messrs. Oswald, Mordaunt & Co. (builders of the engines of the Elbe) still cling to the belief that the bursting of the steam pipe was caused by the water collected in a bend, and are sustained in that opinion by the fact that water did collect in large quantities. This was recently proved by fitting a water trap to the pipe near the bend.

FEBRUARY 3. Brazing and welding with oxygen gas; letter.

The process has been in use some months in London. The gases are under pressure and mixed before arriving at the point of ignition. This gives better results than the ordinary arrangement of the oxy-hydrogen blowpipe.

FEBRUARY 10. Brazing and welding with oxygen; letter.

Describes form and proportions of blowpipe used.

Rapid firing arms (continued).

FEBRUARY 24. Rapid firing arms (continued). W. F. W.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

VOLUME VII, No. 1. Index to current literature.

No. 2. Present aspect of the problem of American inter-ocean ship transfer, by Robert Moore.

A short and interesting review of the canal question.

The calculation of plate girders, by A. Münster.

The author gives three new formulæ for which he claims greater accuracy than is attainable with those in general use.

Index to current literature.

No. 3, MARCH, 1888. Triple expansion engines for lake service. The volt, the ohm, and the ampère.

A paper by Prof. Nipher on the evaluation of the ohm and the relation of the three electrical units mentioned.

Testing the strength of engineering materials. H. S. K.

JOURNAL OF THE U. S. CAVALRY ASSOCIATION.

VOLUME I, No. 1, MARCH, 1888.

The first number of this journal, published by the Association at its headquarters, Fort Leavenworth, Kansas, comes to us replete with useful and interesting information for the cavalry branch of the army. It contains also the constitution and by-laws of the Association, which in their main features resemble very closely those of the Naval Institute. The Journal appears in a very neat and appropriate dress, and the publication committee are to be congratulated upon its handsome appearance. We predict for the Association a prosperous career. C. R. M.

JOURNAL OF THE FRANKLIN INSTITUTE.

VOLUME CXXIV, No. 744. Forbes's electric meters. Flash-light photography.

VOLUME CXXV, No. 745. Early forms of electric furnaces. The gramophone. Electrical measurements, especially as applied to commercial work.

No. 746. A review of progress in the arts and manufactures in 1887.

No. 747. Pig iron; including the relation between its physical properties and its chemical constituents.

No. 748. The pilot chart of the North Atlantic Ocean.

An excellent article contributed by Ensign E. E. Hayden, U. S. N., in charge of the division of Marine Meteorology, United States Hydrographic Office.

J. H. G.

RAILROAD AND ENGINEERING JOURNAL.

DECEMBER, 1887. Spanish cruiser Reina Regente. New Spanish torpedo boats. (Full page illustrations.) J. H. G.

JOURNAL OF THE MILITARY INSTITUTION.

VOLUME IX, NO. 33, MARCH, 1888,

Contains the prize essay for 1886, by Lieutenant M. Woodruff, U. S. Army, entitled "Our Northern Frontiers." This is an interesting paper, full of valuable facts and figures. According to Lieutenant Woodruff, there are five railroad systems in Canada, the largest of which (the Canadian Pacific) is 2893 miles, and the total number of miles of railroad in operation or under construction is 12,449. The military forces can be recruited from about 900,000 effectives, of which 10,600 could be called out in a few hours. The infantry is armed with the Snyder rifle, and the cavalry with the carbine of the same make. The field artillery is armed with the 16-pounder M. L. gun. There are some 400 S. B. guns and some 7-inch and 8-inch modern rifles for garrison artillery, beside the special armament of Halifax and of Esquimault. The naval force of the Dominion consists of eight armed light draft cruisers, and two unarmed despatch boats.

There are four main systems of water communication, the principal one being that of the St. Lawrence and the Great Lakes. It extends 2259¾ miles, 71 miles of which are canals. Of this system only one canal is in the United States. It is proposed to give the whole chain a navigable depth of 14 feet.

The United States has eleven canals in this section of the country. The greatest depth is 17 feet, and the greatest surface breadth 100 feet. The minimum depth and breadth, respectively, are 4 feet and 18 feet, which give the limits of the dimensions of a gunboat or torpedo vessel that can be transferred from the seacoast to the Great Lakes.

The other articles are: "How to Feed the Soldier," by Major W. F. Spurgin; "System of Defense of the Principal Ports of Europe," by Captain T. Tuttle; and a paper on "Mob and Military," by Lieutenant Young.

The discussion of Captain Birnie's admirable monograph on Gun-making in the United States closes this number of the Journal. It is entertaining reading, but throws no new light either upon that excellent paper or the subject of which it treats. A. G.

JOURNAL DU MATELOT.

APRIL 7, 1888. Petroleum motor for small boats.

A system by Lenoir, showing boat with engine, and interior view of motor.

D. H. M.

MINUTES OF THE PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS, LONDON.

VOLUME XCI, 1887–88. Notes on the engineering laboratories

of the Massachusetts Institute of Technology. Propelling machinery of modern warships.

The latter has a valuable appendix, giving details of the machinery of eight of the largest English battle ships, and trials under natural and forced draught.

W. F. W.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVI, Nos. 1 and 2. Fundamental organization of a modern fleet, by F. Attlmayr.

This very interesting article is in the nature of a discussion on an essay by Commander Campbell, R. N., which appeared in the report of the United Service Institution. The author states his own conclusions, which differ somewhat from Commander Campbell's, and gives his reason at considerable length.

Review of maritime legislation and law, 1886–87. The dynamite gun, compiled from different sources, by W. Pucherna. Navigation during foggy weather, translated from *Revue Maritime et Coloniale*, July, 1887. Submarine boats. Estimates for the Imperial Austrian Navy for 1888. Comparative trial trips in Russia with torpedo boats of different builders. Minor Notices: Photographic determination of phenomena in air (preliminary communication by Dr. P. Salcher).

This article outlines experiments which suggested themselves while photographing the disturbances caused by moving projectiles in air. (See Proc. U. S. N. I., p. 263, Vol. XIV, No. 1.) In these experiments the shot remained stationary, and compressed air was forced against it.

Ash-hoisting engine with automatic stop, built by "Schiffs und Maschinenbau Aktiengesellschaft Germania" of Berlin. Experiments with electric apparatus whilst under fire of mittrailleuses and small arms (*Rivista Marittima*). French torpedo boats (*Yacht*). Men-of-war for Australia (*Broad Arrow*). American torpedo boat. Trials at Sandy Hook with projectiles loaded with nitro-glycerine (*Admiralty and Horse Guards Gazette*). Fast steam launch "Buzz" (*Engineer*). Experiments with fluid fuel (*Engineer*). Steel armor. Trial trips of the English armor-belted vessel Galatea and the torpedo cruiser "Archer" (*Admiralty and Horse Guards Gazette*). Use of wire cable for moorings. Castor oil as a lubricator. Inspection of Italian merchant vessels for war purposes (*Esercitio Italiano*). The 30 cm. Ordoñnez gun. Damaged guns of the English Navy (*Revue d'Artillerie*). Trials with the Armstrong rapid-firing cannon (*Iron*). The question of small arms in Russia (*Iron*). A new explosive, emmensite (*Iron*). Mortars for coast defense (*Iron*). Bursting of Hope's gun. The 340 mm. De Bange gun (*Rivista di Artiglieria e Genio*). English steel projectiles (*Iron*). Steel shields for infantry (*Iron*). Armor trials in Spezia (*The Army and Navy Gazette*).

Literary Reviews.

Amongst the books reviewed is one entitled "Estado actual de la cuestion torpederas errores pasados y verdades tardias," por Emilio Sellström, teniente coronel di artilleria, Buenos Aires, casa editoria, L. Jacobsen & Cia., 1887. This work is recommended as worthy of the most careful attention, and is reviewed at some length.

E. H. C. L.

NORSK TIDSSKRIFT FOR SOVAESEN.

SEVENTH ANNUAL SERIES, NO. 5. Theory of the equilibrium of vessels (conclusion by Prof. J. S. Rasmussen). Hospital ships, their arrangement and their employment in the Navy (Dr. Tybring). Waves (from the *Nautical Magazine*). Loss of the English gunboat Wasp (*Revue Maritime et Coloniale*). Manufacture of shell for the American pneumatic gun. English rapid-firing cannon. Trials with the Nordenfelt submarine boat. E. H. C. L.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

NOVEMBER, 1887. Dictionary of explosives (continued, by Maj. J. P. Cundill, R. A.)

Gives a list of explosives, both in use and proposed, their ingredients, and in some cases their manufacture. Useful as a book of reference.

DECEMBER. Siacci's method of solving trajectories, by A. G. Greenhill, M. A., and A. G. Hadcock, R. A.

This method differs but slightly from the one explained in the Text-Book of Exterior Ballistics, in use at the U. S. Naval Academy.

JANUARY, 1888. The Maxim automatic machine gun, by Capt. F. G. Stone, R. A.

Of great interest to naval officers. During 1887 four trials on Continent. In first trial, when Maxim gun appeared on the ground the Gardner gun had beaten all competitors. Gardner gun—weight 200 lbs.; tripod, 100 lbs.; 4 men necessary to handle it. Maxim gun—weight 50 lbs.; tripod, 60 lbs.; one man. Gardner fired 300 rounds in 61 seconds; on attempt being made to fire faster, it jammed, causing delay of 15 minutes. Maxim fired 334 rounds in 35 seconds, and made most hits at 300 meters. At another trial, competing against two-barrel Gardner and five-barrel Nordenfelt, it fired 5000 rounds without a hitch; then submitted to a severe sand and rust test, and did not miss a shot.

MARCH. Foreign attempts at making rifles of smaller caliber, by Maj. W. McClintock, R. A.

Comparing the ballistic qualities of small arms now in general use, caliber .40 to .45, with others of reduced caliber, .354, .335, .315 and .295. A great many advantages in favor of the smaller calibers.

Compressed powder charges with central channel were also used in these experiments. M. K. E.

REVISTA MARITIMA BRAZILEIRA.

NOVEMBER and DECEMBER, 1887. Organization of the meteorological services in Europe. External ballistics. The theory of submarine mines. The use of oil on troubled waters. Also a chronicle containing many interesting articles. D. H. M.

REVUE DU CERCLE MILITAIRE.

FEBRUARY 5, 1888. Military schools in Italy. The Italian expedition to Abyssinia, containing an account and plan of a movable fort.

FEBRUARY 12. Military schools in Italy. Rapid fire cannon of large caliber, experimented with in England at Elswick—one of $4\frac{3}{4}$-inch bore, throwing a projectile 40 pounds in weight, firing 10 shots in $47\frac{1}{2}$ seconds; a second, of $6\frac{1}{2}$-inch bore, projectile 70 pounds, and firing 10 shots a minute. Charges respectively 12 and 30 pounds of powder.

FEBRUARY 19. Plans for artillery firing. War ships launched during 1887. Military schools in Italy (end).

FEBRUARY 26. Plans for artillery firing. Construction of a new style of torpedoes.

MARCH 4. Plans for artillery firing. List of men-of-war being now constructed in England.

MARCH 18. Study of the methods of instruction for infantry fire.

APRIL 1. Study on methods of instruction for infantry fire. Note on artillery fire in groups. New campaign stove for Russian army.

D. H. M.

REVUE GÉNÉRALE DE LA MARINE MARCHANDE.

JANUARY, 1888. The Newfoundland fisheries. Steam engines: new method of governing the slide in oscillating engines (drawings). Brock's system of quadruple expansion. New style of boiler. Non-explosive boiler (drawings), Roberts'. A perfected dredge, Vernaudon's (drawings). The future of Port Said. The port of Antwerp.

D. H. M.

REVUE MARITIME ET COLONIALE.

FEBRUARY, 1888. An article entitled Tonkin. Instructions for rifle practice in the English and Italian navies, compiled from official documents. Campagne of Rio Janeiro in 1711. Obituary notice of Admiral Jauréguiberry. Chronicle—England. Reforms by the Admiralty. The cruisers Mersey, Brisk, and Narcissus. Discovery of an unknown island.* Coal ships attached to squadrons. United States—Trials of the Chicago. Report of the Secretary of the Navy. The naval war college. Project for a naval reserve. Russia—The fleet in the Black Sea. Artillery—A new explosive substance. The best powder for cannon. The Italian 118-ton gun. Comparison between the 111-ton and 118-ton guns.

MARCH. Hurricanes in Madagascar in 1885. End of the voyage in Senegambia. The Italian Navy in 1888. Chronicle—English ships in course of construction: uses for old ironclads. Reconstruction of the Spanish fleet. The Russian fleet in the Black Sea. The pneumatic gun before the Royal United Service Institution: new English cannon. Speed considered as a factor in naval tactics. Crea-

* Reported by the captain of the Samarang. This island is situated west of islands Salam and Timor, 8° 15′ S., 130° 39′ W. from Greenwich. About 2 miles long NNE., and $\frac{2}{3}$ of a mile wide SSW. Low and woody. Not given on any chart.

tion of a Russian war port in the Baltic. The Italian torpedo boat Fatum. D. H. M.

RIVISTA MARITTIMA.

JANUARY, 1888. Historical account of services of Italian seamen under the Spanish flag (continuation). Signal telegraphy. Blockade under present conditions of maritime war. The Quick system of breech-loading cannon (translation from English, with plates). Various professional notes from different periodicals.

FEBRUARY. The Corinth canal.

History of previous attempts to pierce the isthmus, and general description of work now in progress. Time for opening extended from 1888 to 1891, although the promoter, General Türr, looks for the completion of the work in 1890. The voyage from the Adriatic to the Piraeus shortened by 185 sea miles, and that from the Straits of Messina by 95 miles. Amount of merchandise crossing the isthmus in 1881. Advantages to commerce in the increased safety of navigation. General table showing movement of trade in the Eastern Mediterranean in 1885.

Coast defense. The English office of naval intelligence (translation). The pneumatic dynamite gun (translation from English).

J. B. B.

SOCIÉTÉ DES INGENIÉURS CIVILS.

JANUARY, 1888. Solidification of substances under the application of pressures. The consistency and manufacture of cements, mortars, etc. A study of the efficiency of gas engines and the uses of compressed air.

FEBRUARY. The harbor of Saint-Pierre. Reunion Islands. A description of the method now used of welding metals by means of the voltaic arc.

The process, with a short description of its utility and applications. Also a description of a new light of great brilliancy, obtained by burning oil which has been very much rarefied by a current of warm air. It promises wide application to the lighting of work yards, railroad stations, etc., where intense lighting is required for open air work. S. M.

TEKNISK TIDSKRIFT, Utgiven Af Svensk Teknologföreningen.

VOLUME XVIII, NO. 1, 1888. Inventions in Sweden from 1870 to 1884. Review of technical instruction given in 1886–1887. Railway to the southern suburb of Stockholm. Triple expansion steam engines. Manganese elements. Patents issued in 1887 in Sweden, Norway, and Denmark. E. H. C. L.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

VOLUME I, PART II, OCTOBER TO DECEMBER, 1887. Notes on petroleum as fuel; cost as used on the ferry boats at San Francisco, and a useful appendix giving references to articles on petroleum burning. W. F. W.

UNITED SERVICE GAZETTE.

FEBRUARY 4, 1888. Bursting of a 10-inch (38-ton) Armstrong breech-loading gun at Woolwich arsenal.

FEBRUARY 18. Supplement. The Maxim automatic machine gun. Drawings showing the interior of gun, also pictures of the gun in use as field piece, working gun in motion and standing still, gun on tripod, mounted as field piece, and mounted in a wagon drawn by one horse.

FEBRUARY 25. The passage of a river, by Archibald Forster.

MARCH 17. Unsinkable ships.

MARCH 31. Naval mobilization, by Rear Admiral Colomb. A new torpedo boat (No. 49), built by Yarrow & Co.

APRIL 7. The Easter manœuvres—the marching columns.

D. H. M.

LE YACHT.

FEBRUARY 4, 1888. P. 37: The Naval Reserve. P. 41: The accidents to the English torpedo boats. P. 42: Drawings and description of the triple-expansion engines of the steamer Courier.

FEBRUARY 11. P. 47: Life saving boats, system Ponlpiquet. P. 48: Picture and description of Hopkins' luminous buoy. P. 50: View and description of the triple-expansion engines of the yacht Iolanthe.

FEBRUARY 18. P. 53: The Navy in the chamber of deputies. P. 56: Plans and description of the Fatum, a new Italian torpedo boat, built at Leghorn. P. 57: Interesting account of the use of oil on the water in the port of St. Denis, Reunion Island, during a fresh wind which would otherwise have prevented cargo boats going alongside the ship from which the experiments were made. P. 58: View and description of engines for the Queen Victoria, paddle vessel. P. 59: Complimentary notice of the "Pilot Chart" published by the U. S. Hydrographic Office.

FEBRUARY 25. P. 62: The Italian Navy. P. 63: The question of collisions. P. 65: Apparatus for pouring oil on water. P. 67: The road sculler, with description and view.

MARCH 3. P. 71: The speed of the Italia. P. 72: View of two of the four 110-ton guns on the Italia. P. 74: A new means of preserving iron and steel from rust (soapstone, steatite).

MARCH 10. P. 80: Plans and description of a new submarine torpedo boat (electric) invented by Mr. J. F. Waddington.

MARCH 17. P. 85: The English Navy, budget for 1888–89.

MARCH 24. P. 95: Foreign chronicle. P. 96: Plans of a new Spanish torpedo boat, type Azor. P. 97: Description of a new style of compensating compass, by Leon Sirieix, Esq., of San Francisco.

MARCH 31. P. 101: The law in relation to squadrons.

April 7. P. 110: The Navy in the Senate. P. 111: Propulsion by means of hydrocarburet vapor. P. 114: Plans, drawings, and description of the Barcelo, a torpedo boat building at Havre for the Spanish Navy.

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SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1889.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor must send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1889. The name of the writer must not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges shall be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay shall be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, may be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Defense of the Atlantic and Gulf Coasts of the United States.*

7. The essay is limited to seventy-two (72) printed pages of the Proceedings of the Institute.

8. All essays submitted must be either type-written or copied in a clear and legible hand.

9. The successful competitor will be made a Life Member of the Institute.

10. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

CHARLES R. MILES,
Lieut., *U. S. N.*, *Secretary and Treasurer.*

ANNAPOLIS, MD., *March* 1, 1888.